The Status of the Conch Industry of Belize

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ABSTRACT

In the past 17 years Belize has developed one of the most productive conch fisheries in the Caribbean. Since 1973, however, signs of overfishing have become apparent from rapidly declining catches. In response, the Fisheries Unit introduced regulations in 1977 which specified the legal size of conch, the "market' clean" meat weight and established a 3-month closed season. It was believed at the time that these regulations might need to be refined once a sufficient period had elapsed to monitor their effect on the industry.

A 3-year IDRC/Belize Conch Optimization Project was begun in 1980. The Project's main emphasis is to gain increased knowledge of the biology of the queen conch with particular reference to its ecological requirements and population dynamics in Belize. An educational program for the fishermen and other community groups is based on the results of the biological studies. Also the development of an associated industry using discarded conch shells to produce jewelry and other shellcraft is also being strongly encouraged.

The program has value in the development of an efficient management scheme for the industry, in providing feedback as to the adequacy of present regulations and could provide vital information necessary to restock areas with conch reared in hatcheries.

In the past 17 years Belize has developed one of the most productive conch industries in the Caribbean. This development has been largely influenced by the demand of the U.S. market, with exports increasing from 100,000 lb in 1965 to a peak in 1972 of 1.25 million lb. Since 1973, however, signs of overfishing have become apparent with catches rapidly declining to an export low of 251,400 lb in 1981.

In response to this declining production, the Fisheries Unit introduced regulations in 1977 which limited legal sizes of conch catches to 7-inch shell length or 3 oz market-clean weight, and established a 3-month closed season extending from 1 July to 30 September.

At the time it was believed that these regulations might need to be refined after a sufficient period had elapsed to allow their effect on the industry to be monitored. Thus support requested from the International Development Research Centre (IDRC) of Canada in 1979 to set up a conch research project in Belize was eagerly accepted. This Belize/IDRC Conch Optimization Project is now entering its third and final year of operation.

The Project's main emphasis is to gain increased knowledge of the biology of the queen conch *(Strombus gigas)*, with particular reference to its population dynamics in Belize. Two research sites have been set up near the headquarters base in San Pedro, Ambergris Caye. In addition, a nationwide conch tagging program has been commenced from five tagging sites. Coupled with the biological studies, the Project is also involved in an educational program for fishermen and other community groups.

PROJECT PROGRESS AND RESULTS

Tagging

The country-wide tagging program may be considered the cornerstone of the Project. Results from returned tagged shells should yield data on growth rates, migratory patterns and mortality rates. The aim is to tag at least 5,000 individuals, with anticipation of a 3-7% recovery rate. To ensure that the recovery rate is high enough,

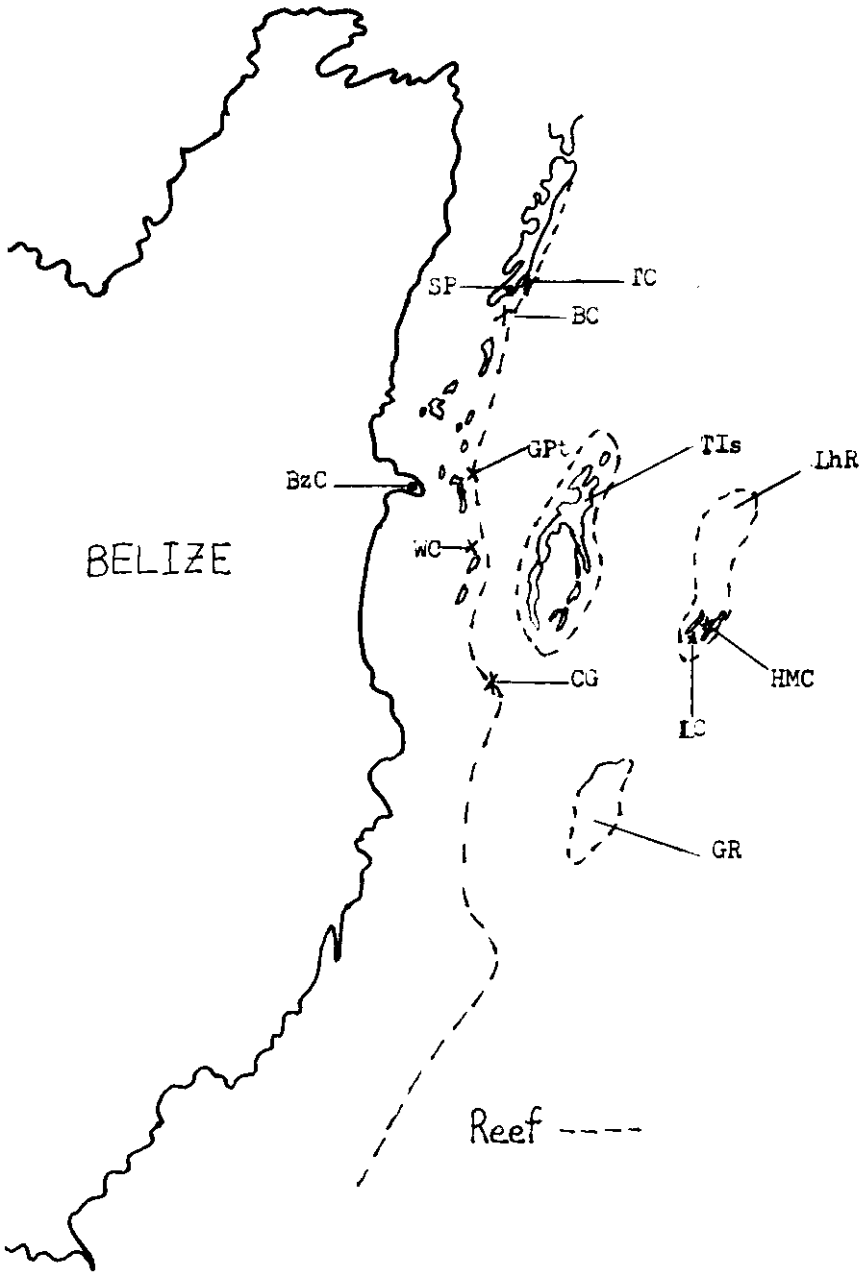

Figure 1. Map of Belize with locations of research and tagging sites: TC, Tres Cocos; SP, San Pedro; BC, Boca Chica; TIs, Turneffe Islands; BzC, Belize City; GPt, Gallows Point; WC, Water Caye; LhR, Lighthouse Reef; HMC, Half Moon Caye; LC, Long Caye; CG, Caye Glory; GR, Glovers Reef.

an extensive publicity campaign is being conducted to inform fishermen about the rewards available for returned conch shells. A reward of $1.00 is given for each tagged shell, and with each return a fisherman is entitled to enter a lottery in which he may win cash prizes of up to $100.00. Fishermen may return their empty tagged

shells either to their respective co-operative or directly to the Fisheries Unit. They are requested to fill out a form supplying the tag number, date and area of capture, color and condition of the returned conch.

In addition to the two research sites, five tag sites have been selected thus far (Fig. 1). The criterion for selection of sites is a population with a high juvenile density. However, some tagging is also carried out in sites supporting a reasonable proportion of adults to obtain comparative data and maintain the fishermen's interest in the reward system.

At each site, three 50 m x 2 m belt transects are laid down randomly and ecological factors, such as bottom type and grass density, depth, salinity, temperature and conch density, are observed and recorded. Conch behavior and presence of predators are also noted and photographs are taken.

Each site is mapped as accurately as possible and the animals are tagged, their length and lip thickness measured, and then redistributed in the same areas from which they were collected. Accurate location of the sites will enable migratory patterns to be studied. Also, it will facilitate future visits to the sites in case the returns from fishermen are low.

Originally, spaghetti tags threaded onto monofilament line were tied around the spire. Preparation and attachment of this tag type was very time consuming and the tag was soon camouflaged by epiphytic growth.

Presently, labelled spaghetti tags threaded with nylon-coated stainless steel wire are being used. Two holes are drilled in the edge of the whorl above the last row of spines. The wire tag is threaded through the holes and secured by a sleeve crimped tightly to the shell (Fig. 2). These tags are quicker to apply and are much more conspicuous in the field. Shell material is quickly laid over the holes and the tag loop inside the shell, and the animal's growth does not appear to be hampered.

The data collected at the tagging sites have revealed the population length structures shown in Table 1. These data show that the length distribution of the populations does not vary a great deal. The length of the conch at Water Caye and Caye

Figure 2. Wire tag attached to conch shell.

Table 1. Sample size, mean, range, mode, median and standard deviation of conch from tagging and research sites (Length measurements given in cm)

Tag Site	n	$\bar{X}$	Range	SD	Median	Mode
Water Caye	443	10.2	7-18	2.1	10	9
Caye Glory	558	10.6	7-25	3.2	9	9
Gallow's Point	384	13.1	4-22	1.7	13	13
Half Moon Caye	425	13.5	8-21	2.7	13	12
Long Caye	30	21.4	14-27	2.7	23	22
Boca Chica	755	12.97	7-25	3.5	13	12
Tres Cocos	1016	11.2	5-24	1.4	10	9

Glory sites both have modes at 9 cm and very similar means (Table 1). However, they represent very different habitats. Water Caye borders a mangrove area and some of the conch are found among the mangrove roots. The soft bottom consists of a very fine silt with a dense cover of *Halimeda* and a sparse cover of *Thalassia.* Cays Glory, on the other hand, is near the reef crest. It has a carbonate sand bottom with a moderate cover of *Thalassis, Syringodium* and *Lobofora.*

Both the Gallow's Point and Half Moon Caye sites were characterized by larger animals (means of 13.1 and 13.5 cm respectively) and sandy bottom types. Half Moon Caye has a moderate cover of *Thalassia* and sparse cover of *Syringodium. Halimeda* occurs here in dense patches. Gallow's Point has a sparse to moderate grass cover, a dense cover of *Halimeda* and *Penicillus* and dense patches of coralline algae.

These sites had high juvenile (i.e., conch without a lip) densities. For example, maximum densities at Gallow's Point, Water Caye and Caye Glory were 80, 52 and 38 per 100 m^2 respectively.

No juvenile beds were located at Long Caye. Instead, a large area comprised of a variety of bottom types was surveyed and only 30 adult conch were found.

Biological Studies

The Project has established two major research sites near San Pedro, Ambergris Caye (Fig. 1) where more detailed studies of the conch are being carried out. One of the objectives of the project is to obtain information on conch life history and its biological requirements that would provide data for rational management. Population density work will be emphasized because Berg (1981) has underlined the importance of determining the preference of conch for different substrates and hence the carrying capacity of varying substrate habitat.

The first site, Tres Cocos, is approximately 2 miles north of San Pedro village and

is mainly a juvenile area. For this reason it is not heavily fished at present. It is hoped that this area will be declared a marine reserve in the near future, thus allowing the present studies to continue over a long period without interference from fishing pressure. This site was chosen as being representative of the general area upon the completion of an extensive survey along the inner reef of Ambergris Caye. Aerial photographs have been taken of the site and these will be used to prepare a detailed map of the area depicting the major bottom types present and allowing accurate plotting of individual conch movement.

A series of 15 belt transects has been laid down from the beach to the reef crest at 100 m intervals to encompass the entire juvenile bed. Random samples, using a 100 m^2 quadrat, are taken monthly. Studies are being carried out to determine the optimum number of samples, stratified according to bottom types, which, on the basis of an initial survey of the entire juvenile bed, have been divided into four main classes: beach, sand, grass and rubble.

The following data are noted for each quadrat: (a) details on bottom type (description of grass, algae, sediment, detritus and general topography), (b) number of conch and (c) presence of other conspicuous animals (e.g., predators). Descriptions have been quantified and are recorded according to a predetermined index.

Conch occurring in each quadrat are tagged to determine growth rate and movements. The length frequency results found to date from these sampling studies are shown in Table 1.

The second study site is located at Boca Chica southeast of San Pedro village, in an area near the reef crest. Fishing pressure at the Boca Chica site is moderate. A number of environmental parameters makes this site very different from Tres Cocos. As a result it provides a good comparative study.

Sampling is being conducted randomly on a monthly basis. A 50 m x 2 m transect is laid down within the study area which is approximately the same size as the Tres Cocos site. The number of conch and the same general environmental factors observed at Tres Cocos are recorded at 10–m intervals. The length structure of the Boca Chica population is shown in Table 1.

The rather limited recapture data achieved so far have been used to determine an approximate growth rate. The rate for each 2 cm size interval was calculated separately. From these initial results it appears that the growth rate does not vary substantially in animals from 8 to 24 cm. The average growth rate was 8.4 cm/year. This compares well with the 8.99 cm/year growth rate calculated by Blakesley (1977).

Gonad Studies

The determination of size at maturity and of the spawning season are among the most important studies on which to base sound management. Therefore, a major aspect of the Project is geared towards the study of gonad development.

Samples of 50 adults conch (those with a thickened lip) have been taken monthly from July 1981 to October 1982 from one large population south of San Pedro (Fig. 1). In May 1982 gonad sections were also made of a sample of various sizes of conch in order to determine length at maturity. It has been decided to continue these samples on a monthly basis for another year to ensure that the spawning season is included (Table 2). Thus, beginning in July 1982, half the sample collected for sectioning were adults with thickened lips and the other half legal sized juveniles without a lip.

The following measurements are made and recorded for each conch sampled: total weight, shell weight, "soft" part weight, market cleaned weight, maximum shell length (measurement from apex of spine to most distant edge of anterior siphonal canal), body whorl length (measurement from midpoint of spines on last

whorl to edge of siphonal canal), body whorl width (midpoint of spines on last whorl to base of shoulder of lip) and lip thickness.

Table 2. Length frequency relationships of lipped and unlipped conch and length at maturity as determined from gonad studies (July 1981-October 1982)

Length cm	No. of Specimens with lip ♀	with lip ♂	without lip ♀	without lip ♂	Length at Maturity
12		1			
13		2			
14	1	6		4	5
15	1	3	4	7	12
16	1	2	4	9	21
17*	2	10	9	11	25
18	5	11	10	5	16
19	11	29	12	6	19
20	24	35	18	12	21
21	34	45	12	9	22
22	59	51	5	8	14
23	55	32	11	1	14
24	42	14	2		6
25	13	2	1		2
26	7	0			0
27	1	1			1
	256	244	88	72	178+

*17.6 cm (7 in) current minimum size limit.
+79 males; 87 females; 12 unknown.
Conch with a well developed lip, but which were less than 18 cm in shell length, were "Samba" or dwarf variety conch. Gonads of 41 "Samba" have been sectioned thus far (n=675).

The object of the shell morphology measurements is to determine if any relationship exists between gonad development and shell morphology. Other factors which may be determined are presence of sexual dimorphism, size of sexually mature animals, relation of market cleaned weight to shell length, and an index of various stages of gonad ripeness. To date, 675 individuals have been sampled and the sex ratio is essentially 1:1.

To measure the soft parts each conch is first "knocked." This involves making a slit in the shell just above the penultimate whorl of spines. The columellar muscle attachment is then severed from the axis with a knife and the animal is carefully removed from its shell making sure the gonads remain intact. The animal is cleaned by cutting off the viscera, slitting the mantle open and skinning it off the body. The

operculum, snout and eyes are removed, and the esophagus is cut open and scraped clean, leaving only the foot and columellar muscle with a fragment of skin on it.

Gonads are sectioned and fixed for future analysis by light microscopy. Sectioning is done with a hand-held razor. Two 2 mm thick cross-sections of the gonad and digestive gland are made approximately 2-3 mm away from the transparent window of the stomach (Fig. 3). The sections are placed in labelled tissue caps and immersed in Davidson solution. After fixation for 24 h, the sections are rinsed in Davidson solution minus its acetic acid component. The anterior sections are stored in Belize.

The posterior sections are sent to the Pacific Biological Station in Nanaimo,British Columbia, Canada, where slides are prepared from the material. A CUSO volunteer working with the Project will be analyzing these slides at a later date to determine the spawning season and other factors related to conch gonad development.

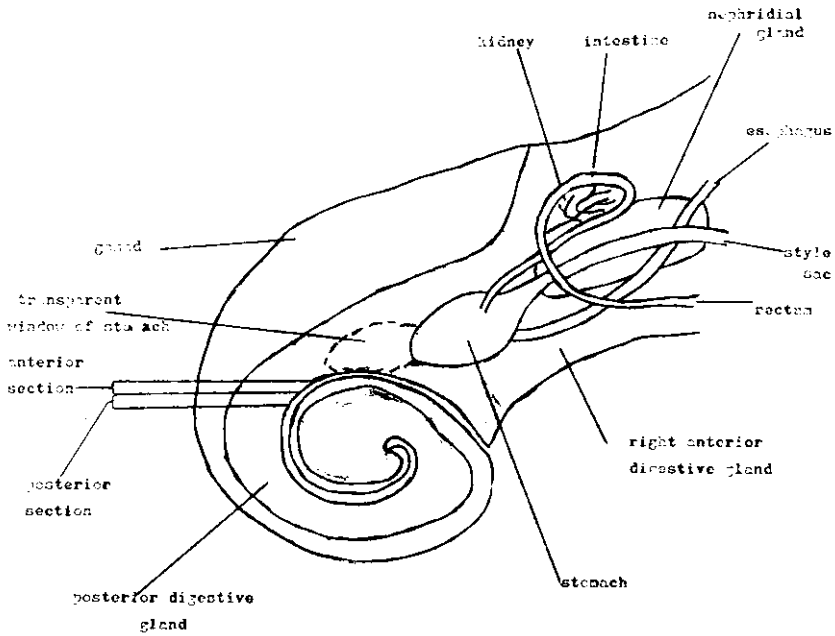

Figure 3. Diagram of conch visera showing area of gonad sectioned.

Educational Program

In conjunction with the biological research, an educational program aimed specifically at the fishermen is being carried out as part of the overall Project.

It is imperative that the users of the resource are included in the work of the Project. Hence a major aspect has been the formulation of a slide show presentation which explains the general biology of the conch and outlines the work being conducted by the researchers. Similar presentations have been given to school children, some of whom will be the fishermen of the future.

The success of the tagging program depends directly on the good response of fishermen in returning tagged conch to their co-operatives. To ensure that they fully understand the importance of this program, colorful posters in English and Spanish have been displayed at the fishing co-operatives and in the community centers of fishing villages. In addition, flyers explaining the tagging system in more detail have

been distributed to fishermen. The Project took the opportunity of advertising its work by having a brief progress report distributed by the fishing co-operatives at their 1982 annual general meetings.

Questionnaires have also been distributed to fishermen and the executive managers of the fishing co-operatives in an effort to gain as much knowledge as possible on all aspects of the conch fishery.

Every opportunity is taken to involve the fishermen in the Project. For example, their help and cooperation have been elicited in mapping areas of juvenile concentrations and in collecting adults for the gonad samples. It is believed that the development within the fishing community of a greater understanding of conch biology and the need for management of the fishery will be an important step in the revitalization of the industry.

The development of an associated industry using discarded conch shells to produce jewelry and other shellcraft is also being strongly encouraged. In 1981 IDRC sent a cottage industry consultant from the Philippines to Belize to instruct the local craftsmen on utilizng conch shell in shellcraft. Seminars and workshops were held throughout the country and since then a number of attractive items made of conch have been seen in the giftshops.

Future plans include a series of radio talks on the work of the Project and the establishment of the Tres Cocos Study Sites as a marine reserve.

CONCLUSIONS

Although the conch catches in Belize have continued to decline steadily since 1972, the results of a general survey of the fishing grounds conducted in early 1981 indicate that there are several areas in which healthy recruitment is occurring. It is believed that if the present regulations could be improved and properly enforced, the industry could be rejuvenated without the need for artificial seeding.

Judging from the results of research completed thus far, it would appear that the presence of a lip on the conch would be a better measure of ensuring sexual maturity than the current size limit of a 7 inch (17 cm) shell length. The average length of conch with a fully formed lip is 23.4 cm with a market cleaned weight of 110 g. A conch size of 22 cm was found to be most economical in terms of maximum meat to total weight (Blakesley, 1977). However, at this size conch may not be sexually mature. A large percentage of immature conch can be legally harvested at the current size limit if lipless conch are considered sexually immature. This contention is supported by our sample data and the work of Blakesley (1977) in Belize. He found that 94.5% of the conch without a lip were sexually immature.

While our gonad studies have not progressed enough to assert that all lipless conch are immature, it is clear that a significant portion of the lipless population is legally harvestable. In our 1981-82 samples, 70% of the lipless conch, or 14.8% of the total of the lipped and lipless specimens, were greater than the 7-inch minimum length (Table 2). These limited data also document that, in this sample, one-third of the mature conch were smaller than the minimum size limit. These preliminary findings on the sizes of lipless conch and size at maturity imply that a review of the present legal size limit—as was originally anticipated—appears warranted.

Results from the gonad studies should pinpoint any seasonal peak in spawning, valuable information when designating closed seasons.

Further studies need to be completed before assessing the maximum sustainable yield for this fishery. On the basis of this factor, it may be decided to introduce an export quota system as a management tool, following the practice currently used for the lobster fishery.

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