An Assessment of the Queen Conch (*Strombus gigas*) Stock of Chinchorro Bank, Mexico

ERNESTO A. CHÁVEZ
Centro de Investigación y de Estudios Avanzados, I.P.N. U.
Mérida, A.P. 73
Cordemex, Yucatán, México 97310

ABSTRACT

The most important stock of queen conch of Mexico has been exploited at increasing intensity at Chinchorro Bank for several years. However, the depletion of the population was evident and then the Fisheries Ministry assigned a catch quota to each of the two groups of fishermen unions of the area (approximately 150 men), exploiting 52.4 tons, throughout seven months of each one of the last three years. The over exploitation of this resource continued, and last June 1990, an indefinite closure of the fishery was decreed, until the resource shows signs of recovery. For this reason a quick survey was carried on with the purpose of determining the condition of the stock in order to give some preliminary recommendations for the management of the fishery. Population parameters were estimated as follows, for the von Bertalanffy growth model, L = 215 mm; k = 0.24, t_0 = -0.05. Mortalities, Z = 1.42, M = 0.1855, F = 1.2345. Exploitation rate, E = 0.66. These parameters lead to an estimate of the exploited population size of P = 558,000 adults, which are composed of only two age classes (III and IV). Even though some areas of juvenile recruitment were found in the study area, much further surveys must be done in order to obtain more accurate estimates to ensure a long term sustainable yield. Each cohort size of the population was simulated stepwise throughout every year of catch records available; and then trends in fishing mortality, exploitation rate and recruitment could be derived. Results of simulation show that the stock is mostly based upon the exploitation of the three year-old recruits and that it has been heavily over exploited since the last 15 years.

KEYWORDS: Queen conch; population dynamics; simulation model; fishery; northwestern Caribbean.

INTRODUCTION

The exploitation of this resource has been very significant along the Caribbean (Berg, 1976) and a resource traditionally exploited in southeastern Mexico for long time due to its accessibility. The increasing demand due to the explosive expansion of touristic activities throughout the last seventeen years has heavily threatened the queen conch stocks not only as a resource for exploitation, but also menacing its persistence as living species. Catches have not increased to the same rate as the demand for it, and at present stocks show evidences of depletion, decreasing from 315 tons of conch meat in 1975 to 77.8 tons in 1983 (Diaz-Avalos, 1989), dropping to only 52.5 tons in 1989.

THE FISHERY

Even though the fishery of *Strombus gigas* has been carried on for many decades, through the last decade the main fishing gounds have been the coral reefs along the so called Great Atlantic Reef Belt (Ginsburgh and Choi, 1983) along the Mexican Caribbean shoreline, and in particular, Banco Chinchorro, near the Belize border where conch stocks are exploited by about 150 fishermen organized into two groups.

Due to the first signs of depletion, local authorities applied the first regulations for the management of the resource: a closure of the fishing season for three months every year, and more recently an additional fishing quota of six tons of conch meat each fishing month. Apparently these regulations have not produced the desired results, and last June the Ministry of Fisheries decreed a permanent closure of the fishery.

None of the management actions has been based upon assessments of the population; however, the depletion of this resource seems to be real, and Chinchorro Bank is the last refuge of the remaining stocks along the Mexican coasts. This was the reason this assessment was done, in order to estimate the real magnitude of the problem of the fishery which has also become a social problem because the groups of fishermen exploiting it depend on the conch fishery as their main source of income.

MATERIALS AND METHODS

Banco Chichorro is an atoll-type coral reef (Fig. 1) rising from the oceanic depth and forming a ring-shaped surf ridge of active coral growth, surrounded by a shallow lagoon about 10m deep in its southern area and only 2 meters on its northern zone (Jordán and Martin, 1987).

Samplings were made on the middle lagoon of the Bank in order to record actual densities, and nine transects were made on three areas, the first one being located on the west lagoon where two transects were made. The second area was located on the East lagoon with four transects, and the third sampling area was one kilometer north of the last one (also on the East lagoon), where three counts were made. Each transect consisted of a line 120m long and conch counts were made at each side of it on one-meter wide bands running along the line. Sampling depths were about four meters in all cases.

Besides density counts, length-frequency samples were taken in order to determine size structure of the population. Data obtained were processed in order to estimate growth rate by fitting the von Bertalanffy growth model (Ricker, 1975; Pauly, 1981). Once age structure was determined, cohort structure was determined and mortality rates were estimated. Natural mortality was calculated following the decline of numbers between the two juvenile age groups identified. Fishing mortality estimates were done after the decline of numbers of the third and fourth age groups observed, which are the exploited ones.

Once the parameters of growth and mortality were determined, the most likely age structure of actual exploited population was established, after a transformation of catch data expressed in weight, into their corresponding numbers, by using the regressions provided by Berg (1976). Secondly, the highest catch value recorded (in 1975) was used as a basis to determine the most likely age structure of the population that year and its fishing mortality was also estimated. A stepwise simulation was conducted and in order to do this the same iteration process was followed in reconstructing the age structures of the queen conch stocks in other years where there were fishing records available.

This procedure enabled the estimation of other population parameters such as exploitation rates and population sizes for each one of the 13 years of catch data available; it was also possible to follow changes in recruitment throughout time.

Equations applied were as follows:

Survival rate $N_t = N_0 Exp\,(-Z_t)$

Population size $P = \sum_{t=r}^{t=13} N_t$

Exploitation rate $E = F/Z\,(1-Exp(-Z))$

Catch $C = P\,E$

where

N_0	=	Initial number of individuals
N_t	=	Number of individuals of age t
Z	=	Instantaneous total mortality coefficient
F	=	Instantaneous fishing mortality coefficient
E	=	Exploitation rate
P	=	Population size
C	=	Catch
t	=	Age (years)
r	=	Recruitment age (3 years)

Unfortunately there are no records of fishing effort, and the procedures here employed were the only possible ways to tackle the stock assessment problem with very scarce information.

RESULTS

The survey to estimate densities indicates a heavy depletion of the population on the Bank. In 1984, based on my own data, queen conch was observed to be very common all over the lagoon area (width: 12 km and length: 48 km). Samplings made in August 1990 show that the conch is now very scarce, and the remaining adult stock is found only on the west side of the lagoon and on the slope of its neighborhood. No conchs were found on the lagoon on the west side of Cayo Centro, and an area of recruitment of juveniles was observed on the East lagoon, very close to the passes (Figure 1). Densities found in three small localities ranged from 0.122 m^{-2} to 0.905 m^{-2} for juveniles and to 1.07 m^{-2} for adults.

Length-frequency analysis (Figure 2) showed that adult population is composed by two age classes (III, IV), even though they are not well defined, which may be due to the difficulties of the separation of age groups in adults (Appeldoorn, 1987a, b). However, juvenile sizes are well sorted and ages I and II were easy to determine, as can be seen in Table 1 where the key relating mean length to age is shown. This outcome made it possible to fit the von Bertalanffy growth model, as it is shown in Table 2, and the longevity of the population (3/k), which is 13 years. Due to the variability of the population, differential growth rate showed that adult stage was reached at the ages of 2 and 3 years, confirming observations made in other parts of the Caribbean (Appeldoorn, 1987b, 1988; Diaz-Avalos, 1989).

Once age classes as well as growth rate were determined, mortality coefficients were estimated. The clear separation of age classes found in samplings allowed the estimation of survival, finding that the portion of juveniles corresponds to natural mortality (M) while that of adults which coincides with the exploited part of the stock, corresponds to natural plus fishing mortality (F). Therefore, F was determined by sustraction of the M value from the total mortality coefficient found. This way, M = 0.1855 and F = 1.237 for the 1989 – 1990 stock (Table 1).

Catch values of the year 1975, when the highest catches were recorded, were six times higher than those of 1989 when only 52.5 tons were caught. Therefore, a simulation of the population was made assuming that all the 13 age classes expected to survive in the virgin population were present in the stock exploited in 1975. The next step followed was to estimate through an iteration process, the most likely age structure, the fishing mortality coeffcient, exploitation rate, and population size for that year. Validity of this procedure was made through the exploitation of the simulated cohorts of that population and the estimated catch values matched to those recorded in statistics. The process was carried out with the stock of every year where statistical catch records were available and in this way it was possible to determine fluctuations and anomalies in recruitment of juveniles one year olds to the stock (Figure 3).

By assuming that natural mortality rate is constant, the F values estimated for the period of catch data ranged from 0.58 in 1975 to 1.11 in 1983 (Table 3);

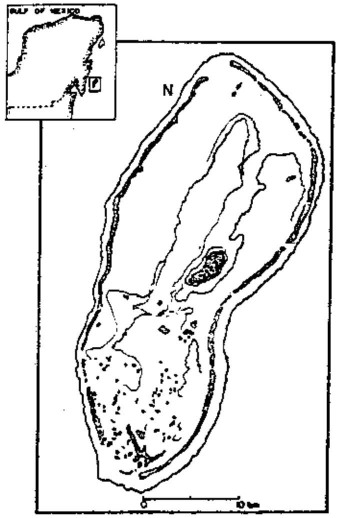

Figure 1. Chinchorro Bank, the study area on the North Western Caribbean

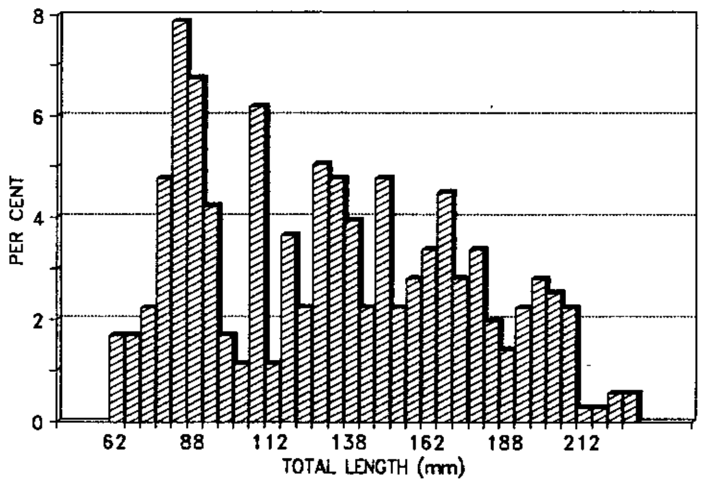

Figure 2. Total length-frequency distribution values of conchs after samplings made in the lagoon of Chinchorro Bank.

Table 1. Length to age key, numbers (N_t) of each cohort in the sample and total mortality coefficients estimated for the queen conch of Chinchorro Bank. In the first mortality value, Z = M, in the second one Z = M+F.

Age Class	Total Length (cm)	N_t	Z
I	80	125	
II	130	102	0.1855
III	170	86	
IV	195	38	1.4225

Table 2. Parameters of the von Bertalanffy growth model found by fitting sampling data. Estimations made by other authors are included for comparison purposes.

L (cm)	W (g)	k	$-t_0$	Source
17.0	605	0.208	0.09	Alcolado, 1976
23.5	1340		-----	Alcolado, 1976
20.0	1104	0.529	0.002	Berg, 1976
26.0	4518	0.501	-----	Berg, 1976
54.9*	-----	0.3706	-----	Appeldoorn, 1988
22.7	-----	0.0824	0.08	Diaz-Avalos, 1989
22.7	2082	0.24	0.05	This Paper

*Lip Thickness

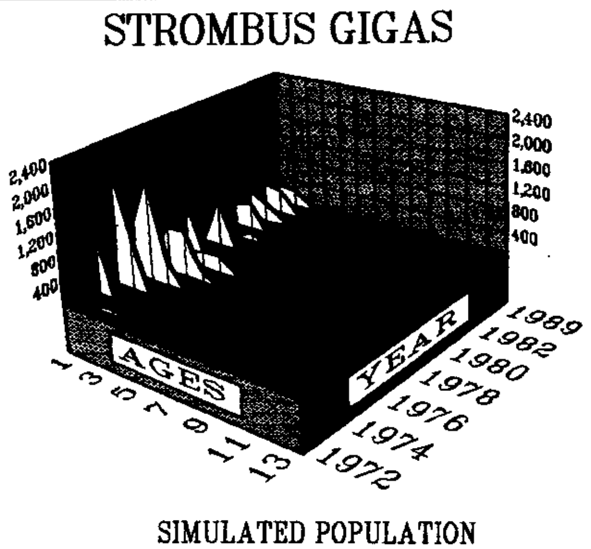

Figure 3. Age distribution of the Queen Conch population determined by means of simulation.

Table 3. Parameters of the *Strombus gigas* stock obtained through simulations. Values for the year 1989 were estimated after analysis of sampling data. Total Mortality (Z), Fishing Mortality (F), Exploitation Rate (E), One Year Old Recruits (N_1), Adult Population Caught (C_s), estimated through simulations, and Adult Population Caught (C) after statistical records. N1, C_s. and C are expressed as thousands of conchs.

Year	Z	F	E	N1	C_s	C
1972	0.75	0.56	0.40	1290	309.9	467.7
1973	0.75	0.56	0.40	2536	152.0	122.9
1974	0.75	0.56	0.29	1117	966.6	966.8
1975	0.77	0.58	0.41	195	2207.4	2207.8
1976	0.8	0.61	0.42	41	1766.9	1767.3
1977	1.0	0.81	0.51	1173	785.1	785.5
1978	1.4	1.21	0.65	8	221.9	221.5
1979	1.6	1.41	0.71	673	859.1	858.5
1980	1.7	1.51	0.73	467	162.3	94.3
1981	1.4	1.21	0.65	607	507.1	506.5
1982	1.35	1.16	0.64	607	455.9	456.3
1983	1.3	1.11	0.62	------	545.6	545.7
------	------	------	------	------	------	------
1989	1.42	1.23	0.66	402	368.0	368.0

these values correspond to exploitation rates E, between 0.29 and 0.73 for the same period and one year old recruits N_1, declining from 2.53 millions in 1973 to only 0.0077 million conchs in 1989, thus reducing severely the turnover capacity of the queen conch population.

DISCUSSION

Queen conch stocks have been studied in several parts of the Caribbean, and mostly because of the relative importance of this species as fishery resource, but also due to its accessibility to fishermen, with makes it very vulnerable (Alcolado, 1976; Berg, 1976; Gibson *et al.*, 1982; Goodwin, 1982; Weil and Laughlin, 1984; Appeldoorn, 1987a, 1987b; Diaz-Avalos, 1989). These efforts have been reinforced with several attempts for its culture, but apparently up to now they have not given a quite satisfactory outcome to ensure a continuous supply of larvae to natural stocks or even for purposes of intensive culture.

Accordingly to what is already known for this species based on studies made elsewhere, densities of juveniles and adults in grounds of its natural habitat, not heavily exploited, can vary from one tenth to about one per sq. m. (Siddall, 1984; Alcolado, 1976). Our findings in the most dense area occupied by the queen conch at Chinchorro Bank lay within the range as those referred in the literature, with the difference that in this case corresponds to the only zones where the conch still remains, though it was remarkable the apparent habitat segregation of age classes which could suggest the possibility of a migrating process, which might be analogous to that found elsewhere (Randall, 1964; Hesse, 1979; Stoner 1989). In the case of further confirmation, the east side of the Bank could be a recruitment zone for young conchs which would stay in the area for about two years before moving to the west side of the lagoon where the most intensive exploitation takes place.

Age and growth of the species seem to be similar along its distribution range on the Caribbean, and based upon the evidences provided by previous workers (Randall, 1964; Weil and Laughlin, 1984; Appeldoorn, 1988; Diaz-Avalos, 1989), our data confirm such statement and furthermore, considering that our age estimates were based upon length-frequency data only, they relay on these antecedents and their accuracy has to be demonstrated after further studies on the resource can be done.

Survival rate is a population parameter dependent from the age-numbers key. However, in this case it is a remarkable finding the fact that the juvenile age classes were well sorted, through which it was easy to estimate the natural mortality coefficient, whose value is within the range found by other authors (Weil and Laughlin, 1984; Appeldoorn, 1984, 1985, 1988; Diaz-Avalos, 1989). With respect to mortality of the adult stage, Appeldoorn (1987b) has stressed the difficulties to get a reliable estimate from samplings of the exploited population due to the extreme difficulty in separating cohorts in adult stages. In this case, confirming the former statement, we must accept to some extent, the chance of some degree of uncertainty of the mortality estimates, based upon length-frequency data only, because the two apparent size groups observed in samples might correspond to males and females, which show a differential growth rate. This is a weak point in the present diagnosis. Anyhow, it must be recalled that the queen conch did not receive any attention in the study area before, and this is the first approach to the knowledge of a resource in conflict that is rapidly becoming a social problem. It is expected that this effort can be useful for further studies which can give a deep insight of the stock assessment of *Strombus gigas* and its rational management. Furthermore, after testing the population numbers caught against those found after the simulation by a t test, no significant differences at any level were found (Figure 4), and therefore the use of this procedure seems to be quite encouraging and offers a stimulating possibility of analyzing exploited populations for their diagnosis with very few pieces of information.

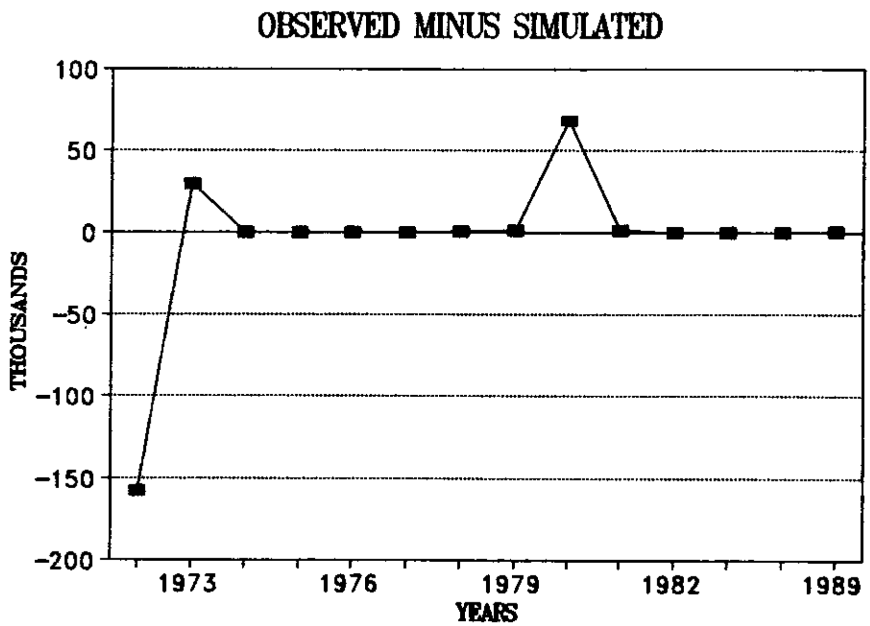

Figure 4. Differences of catch values recorded in statistics minus catch data estimated by simulations.

REFERENCES

Alcolado, P.M. 1976. Crecimiento, variaciones morfológicas de la concha yalgunos datos biológicos del Cobo *Strombus gigas* L. (Mollusca; Mesogastropoda). *Academia de Ciencias, Cuba Serie Biologia.* 33p.

Appeldoorn, R. 1984. The effect of size on mortality of small juvenile conch (*Strombus gigas* Linne and *S. costatus* Gmelin). *Journal Shellfish Research* 4(1): 37-43.

Appeldoorn, R. 1985. Growth, mortality and dispersion of juvenile laboratory-reared conch, *Strombus gigas* and *S. costatus* released at an offshore site. *Bulletin Marine Science* 37(3): 785-793.

Appeldoorn, R. 1987a. Assessment of mortality of an offshore population of queen conch, *Strombus gigas* L., in Southwest Puerto Rico. *Fishery Bulletin* 85(4): 797-804.

Appeldoorn, R. 1987b. Practical considerations in the assessment of queen conch fisheries and population dynamics. pp. 307-324. in F. Williams (ed.) *Proceedings Gulf Caribbean Fisheries Institute.*

Appeldoorn, R. 1988. Age determination, growth, mortality and age of firsh reproduction in adult queen conch, *Strombus gigas* L., off Puerto Rico. *Fisheries Research* 6(1988): 363-378.

Berg, C.J. Jr. 1976. Growth of the queen conch, *Strombus gigas*, with a discussion of the practicality of its mariculture. *Marine Biology* 34: 191-199.

Diaz-Avalos, C. 1989. Crecimiento y mortalidad de juveniles de caracol rosado *Strombus gigas* en Punta Gavilán, Q. Roo. Instituto Nacional de la Pesca. Mexico, Serie Doc. de Trabajo 1(3): 1-16.

Gibson, J., S. Strasdine & K. González. 1982. The status of the Conch industry of Belize. *Proceedings Gulf Caribbean Fisheries Institute* 36: 99-107.

Ginsburg, I. & D. Choi. 1983. Quaternary reefs of Belize, Central America. *Proceedings Inaugural Great Barrier Reef Conference.* Townsville JCU Press: 27-42.

Goodwin, M. 1982. Overview of Conch Fisheries and culture. *Proc Gulf Carib. Fish. Insti.* 36: 43-45.

Hesse, K.O. 1979. Movement and migration of the queen conch, *Strombus gigas*, in the Turks and Caicos Islands. *Bulletin Marine Science* 29: 303-311.

Jordán, E. & E. Martin. 1987. Chinchorro: Morphology and composition of a Caribbean atoll. *Atoll Research Bulletin* 30: 1-32.

Pauly, D. 1981. A selection of simple methods for the assessment of tropical fish stocks. *FAO Cilcular Fisheries* (729), 59 p.

Randall, J. E. 1964. Contributions to the biology of the queen conch, *Strombus gigas. Bulletin Marine Science Gulf Caribbean* 14: 246-295.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. *Bulletin Fisheries Research Board Canada* 191, 382 p.

Siddall, S.E. 1984. Density-dependent levels of activity of juveniles of the queen conch *Strombus gigas* Linne. *Journal Shellfish Research* **4**(1): 1-3.

Stoner, A. 1989. Winter mass migration of juvenile queen conch *Strombus gigas* and their influence on the benthic environment. *Marine Ecology Progress Series* **56**: 99-104.

Weil, E. and R. Laughlin. 1984. Biology, population dynamics and reproduction of the queen conch, *Strombus gigas* Linne, in the Archipielago de Los Roques National Park. *Journal Shellfish Research* **4**(1): 45-62.