Regional Initiative for the Evaluation of Queen Conch (*Strombus gigas*) Exploitation under an Historical Perspective

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ABSTRACT

The queen conch, *Strombus gigas*, is the largest gastropod mollusk in the Caribbean and the Gulf of Mexico. Conch fishing began during pre-Columbian times and continues up to the present, given the high nutritional and economic value of its meat. This fishery has extended through out the region, with signs of overexploitation evident at some localities (i.e., Dominican Republic, Haiti, Honduras). Unfortunately, long-term chronological data for landings of this resource have not been well documented, except for the oldest records at the Turks and Caicos Islands (only about 100 years). However, an excellent indicator of queen conch exploitation is presented in some places by the accumulations of shell remains that can be and have been used in the historical reconstruction of conch fisheries. The intent of the present study is 1) to review and synthesize the cumulative experience through case studies from our research in The Bahamas, Dominican Republic, México and Venezuela; 2) present evidence for the exploitation of this resource during pre-Columbian as well as contemporary times; and 3) discuss different approaches and methodologies, with the goal of stimulating research in this field and offering recommendations for future work.

KEY WORDS: fisheries, middens, landings, size, management.

Iniciativa Regional para la Evaluación de la Explotación del Caracol Reina (*Strombus gigas*), bajo una Perspectiva Histórica

El caracol reina, *Strombus gigas*, es el molusco gasterópodo de mayor tamaño en la región del Caribe y el Golfo de México. Su pesca se inició en la época pre-Colombina y ha continuado hasta la época moderna, gracias a la exquisitez y amplio contenido proteico de su carne. La misma se ha extendido por toda la región, con evidentes signos de sobreexplotación en muchas localidades (*e.j*., Republica Dominicana, Haití, Honduras). Lamentablemente la evidencia cronológica acerca de la evolución de los desembarques de este recurso no ha sido bien documentada, salvo por registros realizados en las islas de Turks y Caicos (>100 años). Sin embargo, un excelente indicador de la explotación del caracol reina está representada en algunas localidades mediante la acumulación de conchas de estos animales, que pueden ser y han sido utilizadas en la reconstrucción histórica de estas pesquerías. El presente trabajo busca aglutinar la experiencia acumulada por estas iniciativas, mediante la presentación de casos de estudio provenientes de Las Bahamas, Republica Dominicana, Venezuela y México. Se presentará evidencia sobre la intensidad de explotación del recurso durante los periodos precolombinos y contemporáneos, a la vez que se discutirán los diferentes enfoques y metodologías utilizadas, con miras a estimular la investigación en este campo y proponiendo líneas de acción para trabajos futuros.

PALABRAS CLAVE: pesquerías, concheros, desembarcos, tallas, manejo.

INTRODUCTION

The queen conch, *Strombus gigas* Linnaeus, 1758, is a large edible marine gastropod mollusk which is broadly distributed in the shallow waters of the Caribbean Sea and Gulf of Mexico (Randall 1964, Mulliken 1996). Archaeological records show that queen conch have been utilized as a food and shell source in the Caribbean basin for thousands of years (DeBooy 1912, Rainey 1941, Olsen 1974, Keegan 1984, 1986, 1992). However, the oldest written records of conch landings are probably for the Turks and Caicos Islands, dating back only about 100 years to 1904 (Doran 1958).

Once second only to finfish as a source of protein in native diets (Brownell and Stevely 1981), the queen conch is now consumed predominantly as a specialty food owing to its rarity and relatively high market value. This is a consequence of heavy exploitation especially during the last 30 years, despite legislation in many countries to manage the

fishery (Mulliken 1996, Posada and García-Moliner 1997). Due to declines in landings, the queen conch was listed as a threatened species by the Convention for International Trade of Endangered Species (CITES; Appendix II) in 1992.

Evidence of pre-Columbian and modern queen conch fishing practices has been left on Caribbean shorelines in the form of shell middens. This kind of shell record is routinely used to evaluate their paleoecology (Matteson 1960, Peterson 1976) and historical exploitation (Cook 1946, Meehan 1982, Keegan 1992, Jerardino 1997, Mannino and Thomas 2002) and complements written records of fishery status.

Conch shell middens and shell artifacts created by fishers ranging from several thousand years ago to the present have been described by numerous researchers working in the Caribbean (*i.e*., Watters *et al*. 1992 in Bermuda; Rainey 1941 in Haiti; Keegan 1982, 1984, Stoner and Ray 1996, Stoner 1997 in central Bahamas; Vega 1987, Torres and Sullivan-Sealey 2002 in Dominican Republic; Carr and Reiger 1980, Reiger 1979, 1981 in south Florida; Adams 1970, Tucek 1971 in St. Vincent, St. Lucia and the Grenadines; Doran 1958 in the Turks and Caicos Islands; Antczak and Mackowiak de Antczak 2005, Schapira 2004, Montaño 2005 in Venezuela). These studies provide important insights into the abundance and distribution of queen conch throughout the region, and clues related to human exploitation.

The present study is designed to summarize the cumulative experience of such initiatives, through the presentation of case studies from the Bahamas, Dominican Republic, Venezuela and Mexico. We also discuss the general approaches that can be taken to gain historical perspective on the ecology and exploitation of queen conch and how shell remains can be used to help answer questions related to fishery management and ecology. We hope that this initiative will stimulate new research in the field and we present recommendations for future work.

RESULTS

Bahamas

Over a period of five years, conch shell middens were systematically searched in the shorelines of all islands, cays and significant rocks around Exuma Sound, Bahamas (Stoner and Armstrong 1992, Stoner 1997). Great Exuma was not searched because the high degree of shoreline development precluded accurate assessment. The largest known fisheries for queen conch in the region occur in the north and west sectors of the sound, in relatively shallow waters both on the banks and on the narrow island shelves bordering the Sound.

During the surveys, all accumulations of conch shells were mapped and midden volumes were calculated. The middens, ranging in size from a few scattered shells up to large piles (3-4 m high, volumes >1700 m^3), were most abundant and largest in the Exuma Cays. They were located in areas protected from the prevailing easterly trade winds, and were associated with tidal passes between islands where there were strong currents and where seagrass beds were extensive.

Radiocarbon dates were acquired for nine queen conch shells collected from the bottom of the five largest middens in the Exuma Cays. Two shells were >400 years old indicating that conch shell middens provide excellent time-averaged information on the distribution and abundance patterns of queen conch and an historical record of fishery utilization. However, detailed analysis of individual middens was not conducted, and future studies should include analysis of conch size and lip thickness.

Midden volume was closely correlated with the abundance of juvenile conch on the shallow shelf surrounding the middens (Figure 1; Stoner 1997). Eighty-nine percent of the variation in midden volume was explained by variation in the size of the surrounding juvenile conch population.

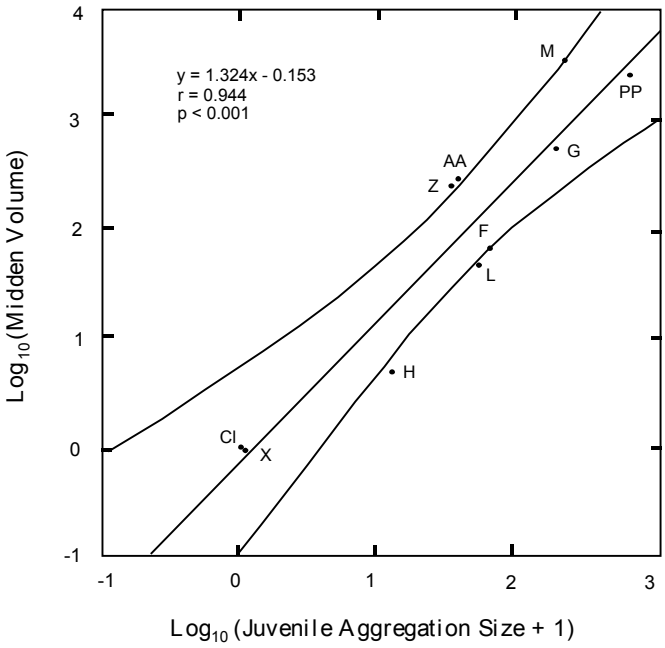

Figure 1. Correlations between the size of the local juvenile queen conch aggregation and shell midden volume. The 95% confidence interval is shown for the regretion line. Letter codes identify the tidal pass systems in the Exuma Cays where surveys where made (Taken from Stoner 1997).

Like the middens, all life history stages of queen conch – larvae, juveniles, and adults – are distributed heterogeneously around Exuma Sound. Stoner *et al*. (1998) incorporated midden data into large-scale interpretation of this heterogeneity (Figure 2). As expected, results showed a positive correlation between adults (*i.e*., spawner abun-

dance) and early-stage larvae. However, correlations between late-stage (*i.e.*, competent, ready to settle) larvae and either juvenile or midden distributions were not significant, and late-stage larvae were present in substantial numbers at one site where juvenile and adult abundance were low. These results suggested that settlement processes and/or early post-settlement processes during the first year of life, related to habitat limitation or predation, drive regional distribution of juveniles and not differences in larval supply.

Dominican Republic

Archeological evidence from primitive colonizers shows that Tainos (indigenous people) began impacting the queen conch population as soon as they became established in the island of Hispaniola (Dominican Republica and Haiti), around 600 A.D. (Veloz Maggiolo 1991). The most accepted range for the Tainos population in 1492 for Hispaniola is between 200,000 and 2 million. However, colonization dramatically decreased this human population by the end of the 16th century, and there were no survivors of this once-thriving indigenous population (Guerrero and Veloz Maggiolo 1988).

Studies to document changes in fishing pressure on a queen conch population were conducted in a marine lagoon of the Parque Nacional del Este (PNE; southeastern corner of Hispaniola), in an area where one of five major Taino provinces (Higuey) occurred and queen conch fishery has been occurred up to the present days.

Excavations of the shell middens were conducted in two separate field excursions during March 2000 and March 2001. Five ancient (CM1-5) and 9 contemporary middens (PM1-9) were mapped. Radiocarbon dating analysis indicated that the oldest shell midden was from around the year 600 (± 70) A.D. (CM1), while the contemporary fishery was established during the 1950's and supported a relatively large export market to the United States, Virgin Islands and Puerto Rico between 1950 and 1970. Presently, the small-scale artisanal fisheries exist for local consumption (Torres and Sullivan-Sealey 2002).

Conch shells were measured in the oldest and most recent middens (2,175 and 4,868 shells in CM1 and PM5, respectively). In both cases, most shells (98%) were *S. gigas* (mean siphonal shell length of 12.2 ± 2.6 cm and 14.8 ± 3.3 cm, respectively), followed by small proportions of *Cittarium pica*, *S. costatus*, *S. pugilis*, *Cassiss* sp. and *Murex* sp. By the presence or absence of a flared lip in the shell, it was determined that 99% and 85% of the *S. gigas* shells were juveniles in ancient and contemporary middens, respectively. A Kruskal-Wallis test showed that there was a significant difference ($p<0.05$) in mean siphonal shell length between all the middens (ancient and contemporary) (Figure 3, from Torres 2003).

Results obtained from contemporary middens indicate that at least 3.5 million queen conch were fished from between 1950 and 1970. This estimate gives an idea of the intensity of fishing pressure at that time. If the queen conch was fished at a rate of at least 175,000 individuals per year and if the available fishing available was 7,582.5 ha, the estimate density of *S. gigas* inside the lagoon would be at least 23 conch per ha. Since this estimate was calculated assuming a constant fishing rate, which is highly unlikely, a more realistic *S. gigas* density would probably be substantially higher at the beginning of the fishery and much lower when the fishery declined and became commercially unsustainable. This argument is confirmed by Towle (1973), who reported that the creation of PNE in the early 1970's was not controversial, because the commercial fisheries in the area had unfortunately already collapsed.

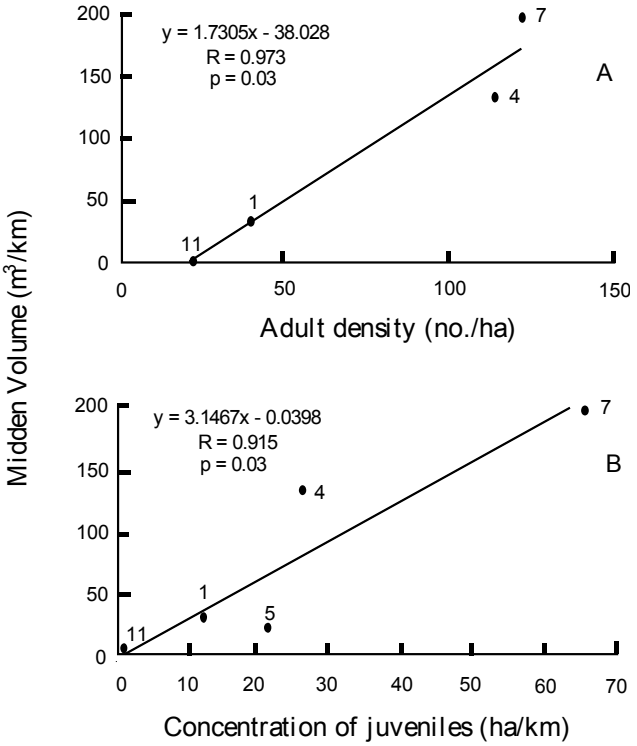

Figure 2. Conch midden volume plotted as a linear function of (A) adult conch density at 2.5 to 20-m depth and (B) concentration of juvenile conch. Pearson correlation coefficients (R) and p-values are given for each regression equation. The number above each point represents the sector at which surveys were conducted in Exuma Sound (Taken from Stoner et al. 1998).

Venezuela

Los Roques archipelago is the only area that allows a thorough reconstruction of queen conch fishing in Venezuela. It is located 135 km north of the central Venezuelan coast. The islands were visited from the mainland by the so called Ocumaroid groups (between A.D. 1100 and 1150) and later by the Valencioid people (between A.D. 1250 - 1300 and the beginning of the European colonization) (Antczak 1999, Antczak and Mackowiak de Antczak 2005).

At the end of the 19th century, Dutch fishermen from the adjacent islands of Aruba, Curacao and Bonaire began to visit Los Roques archipelago, and Venezuelan fishermen from Margarita Island began to settle there at the beginning of the 20th century. According to archaeological and documentary data, the queen conch exploitation during this period was characterized by low intensity and was destined for *in situ* consumption. These early settlers were focused on the exploitation of other local resources such as salt, lime and charcoal (Antczak 1999). In the mid 20th century, the archipelago received a relatively intense wave of migration of fishermen from the Margarita Island, who began to exploit the queen conch and the lobsters commercially.

Los Roques archipelago shell middens were studied between 2003 and 2006, by an interdisciplinary team that included biologists, archaeologists and ecologists. Air reconnaissance (using light aircraft) and pedestrian survey of all islands were carried out. All located middens were photographed, geographically referenced, and characterized with respect to their size, volume, chronology and content (Posada *et al*. 2006). A total of 181 middens were located: 8 pre-Columbian (created between A.D. 1270 and 1450 ± 50) and 173 contemporary (created between 1953 and 2005). The largest ancient middens were located on Cayo Sal and La Pelona islands, while Fernando Island yielded the largest of the contemporary ones.

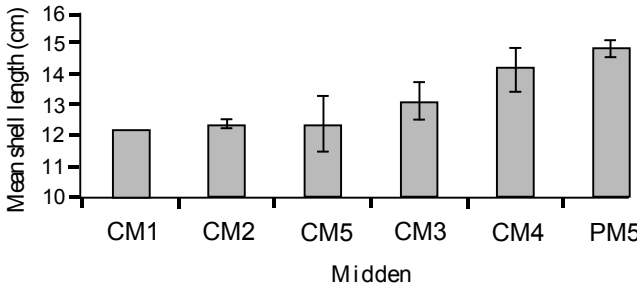

Figure 3. Mean siphonal shell length of *Strombus gigas* shells found in PNE middens during 2000-2001 excavations. Error bars represent the 95% confidence intervals used for the statistical analysis. Middens on the x-axis are chronologically ordered to show changes in shell length through time. The observed increase in shell length may be due to fishermen selection of specific shell sizes (*i.e.*, primitive fishermen had acess only to relatively shallow water where only juveniles occur). There is a significant difference in mean shell length from the different middens excavated in PNE. Sample sizes were as follows: CM1 = 2,175; CM2 = 85; CM3 = 67; CM4 = 468; CM5 = 79; and PM5 = 4,868 shells (Taken from Torres 2003).

The ancient middens were largely composed of adult queen conch shells (80% and 94% in Cayo Sal and La Pelona, respectively). In contrast, an increase in the proportion of juvenile shells was observed in contemporary middens, from 47% between 1953 and 1971 to 69% between 1972 and 1989. No significant changes in siphonal length of adult were observed in shells discarded during approximately 200 years of the pre-Columbian fishery regime (23.4 and 22.1 cm in Cayo Sal and La Pelona, respectively). However, during 50 years of contemporary fishery a decrease in mean siphonal length was observed (La Pelona: from 21.9 to 20.8 cm between 1980/1984 and 1990/95; Isla Fernando: from 22.2 cm between 1944/71 to 21.9 cm between 1972/89 and 20.2 cm during the period 1990/95) (Figure 4, Posada *et al*. 2006).

The overall harvest estimated for the pre-Columbian fishery is low (approximately 5 mt yearly) compared with, contemporary harvest. Beginning in 1953, mean annual production was 10 - 20 mt per year, increasing to 40 or 45 mt between 1964 and 1970. The fishery reached highest intensity between 1970 and 1985, with an annual production of 50 to 70 mt (Figure 5; from Posada *et al*. 2006). By 1987, an abrupt decline in the quantity of ´new´ shells added to the shell middens was observed (Figure 5), which seems to be a direct consequence of the first restrictions to the fishery imposed in 1985. So, the mean annual production between 1990 and 2005 was below 10 mt (Figure 5).

It seems highly probable that, like other areas in the Caribbean, the queen conch population in Los Roques archipelago would have collapsed without the fishing restrictions. Visual surveys conducted by Schweizer and Posada (2006) showed that queen conch populations have been recovering in Los Roques archipelago, both in terms of adult siphonal length shell (increasing from 23 to 24 cm) and density (increasing from 34.7 to 52. 3 conch per ha).

Mexico

The queen conch has been an important fishery resource in the Mexican Caribbean region since pre-Columbian times. Currently, it generates an official annual income of US$ 570,000, with an undetermined income from illegal catches. Due to the high fishing pressure that is exerted upon most of its populations several stocks have been reduced to levels where the population can no longer recover.

Commercial fishery of queen conch has been practiced in the states of Yucatan, Campeche and Quintana Roo (Yucatan peninsula) since the 1950's. However, the record of unofficial landing data began only in 1972 for Quintana Roo and in 1979 for Yucatan. The fishery continues to be important for fishers of Quintana Roo state, but it was closed in the state of Yucatan in 1988, as a consequence of landings decline from 1200 tons in 1986 and still 38 tons in 1990 (Pérez and Aldana-Aranda 2000).

In Quintana Roo, the queen conch fishery has been assigned to three fishing co-operatives, with a total of 142 fishers. It has been regulated with a minimum landing size of 20 cm, catch quotas (30 mt at Chinchorro bank and 12 mt at Cozumel) and a reproductive ban from May 1st to October 31. In Yucatan, fishing occurred at Alacranes reef, but today it is a Marine Protected Area.

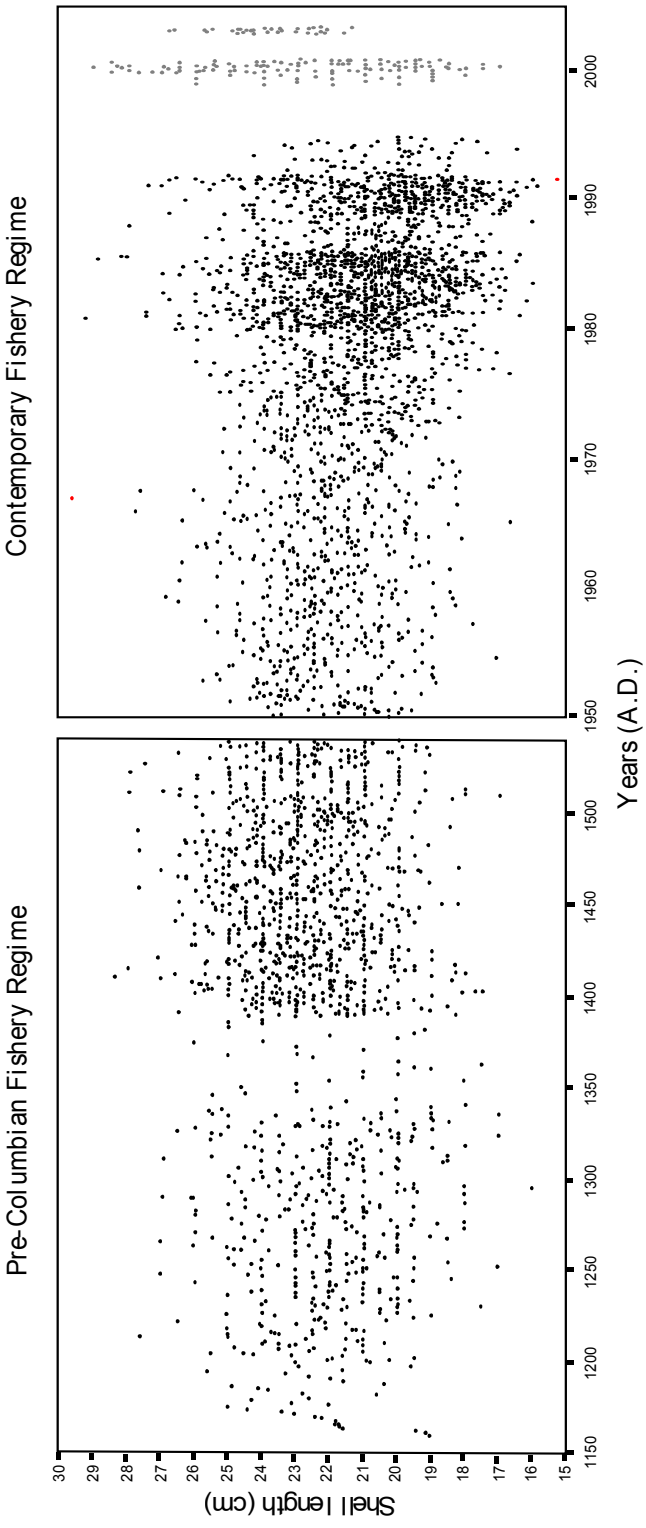

Figure 4. Siphonal shell length of each subadult and adult conch mesuared from all along the pre-Columbian and contemporary fishery regimes (old individual were omited due to shell erosion). Clear dots represent shells from adult individuals mesuared by Cipriani and Posada (2003), Schapira (2003) and Posada (Taken from Posada et al. 2006).

However, illegal catch still occurs today. In general, conch densities have been declining in both states, according to the evaluations conducted by Basurto *et al*. (1996) and Domínguez-Viveros *et al*. (1999) at Chinchorro bank and by Pérez and Aldana Aranda (2000) at Alacranes reef. The number of co-operatives has also been decreasing in both states, indicating that the fishery is no longer commercial sustainable.

DISCUSSION

Historical perspective on queen conch fisheries is gained from two primary sources presented in this review – from modern fishery statistics and from the archaeological record of fishing provided in shell middens. Despite the economic and cultural significance of queen conch in the Caribbean region, records of conch landings usually span only a few decades. Declines in conch landings and conch abundance in the field are well documented, and modern stock assessments provide good evaluations for management practices such as fishery closures, size limits, and gear limitations.

Shell middens provide a much longer historic perspective on the exploitation, distribution, and population structure of queen conch. Study of ancient middens can be particularly fruitful since it is unlikely that early fisherman, without the aid of motor-driven vessels, carried the large, heavy shells far from the fishing grounds. Therefore, middens occur almost anywhere there is an active conch fishery, and they provide a good representation of the surrounding conch populations as shown by Stoner (1997). Analyses of shell middens span several different approaches, ranging from anecdotal mention of middens in early reports to detailed excavations and carbon dating such as those provided by (Torres 2003, Posada *et al*. 2006). These studies reveal historical patterns of exploitation including changes in the sizes and ages of conch landed, evidence for poaching illegal populations and size classes, and possible evidence for shifts in population size frequencies and abundance patterns.

Archeological research shows that the southeastern Caribbean was inhabited by Amerindian populations at least since the end of the Pleistocene (Antczak et al. in press) and that settlements advanced northward to the Greater Antilles. Given that the queen conch was widely used for food in the pre-Hispanic Caribbean it may be expected that future research may mark the south-north direction of the ancient migration route with the sequential dates of the queen conch middens. In most excavations, the sizes of conch shells decrease with time (increased exploitation of subadult and juvenile conchs) and reveal increased fishing pressure and/or over-fishing of queen conch. Research in Los Roques shows that pre-Columbian landings were probably very small compared with those in modern times.

The use of shell middens for historical perspective on queen conch exploitation has three limitations. First, the middens can be lost through natural and anthropogenic

processes. While human exploitation of queen conch is confined primarily to the present inter-glacial stand of sea level, shell middens have probably not been lost to major shifts in sea level. However, shoreline movements over hundreds to thousands of years may result in middens being lost underwater covered by sand, or left in the interiors of land masses. The greatest likelihood for this will occur where human occupation is longest (e.g. several thousand years along the shores of South and Central America) and less likely where occupation has been relatively short (*e.g*., <1000 years in the Bahamas). Middens are also lost to shoreline development. For example, large middens in Nassau Harbor (Bahamas) were destroyed by development on Potter's Cay over the last 20 years. The same is true in all of the important Caribbean tourist destinations and where large populations exist (*e.g*., US Virgin Islands). Shells have also been gathered for use in construction of buildings and roads. When the stratigraphy of middens is disturbed by natural or human-related events, interpretation will depend heavily upon ageing shells by radiocarbon dating or less precise methods. The second limitation is that middens can provide important insights into the history of exploitation and population dynamics for queen conch, but careful excavations are labor-intensive. Furthermore, carbon dates are expensive (*i.e*., recent quotes by analytical laboratories range US$150 to 300 each). Carbon dates are currently available for a relatively low number of shells taken from middens in the Exuma Cays, Bahamas (Stoner 1997), Parque del Este in the Dominican Republic (Torres and Sullivan-Sealey 2002), and Los Roques, Venezuela (Antczak 1999, Posada *et al*. 2006). Finally, the results of midden analyses are often limited to qualitative interpretations because we usually do not know a great deal about fishing practices earlier than about 100 years ago. For example, shells have not always been carried to shore because of their bulk and weight. As an extreme case, today in Puerto Rico, conch meat is extracted underwater by scuba diving fishers. Also, changes in size frequency could be interpreted to reflect a change in the conch population at a site, but an equally viable interpretation may be changing dietary preferences or fishing methods as pointed out by Torres and Sullivan-Sealey (2002).

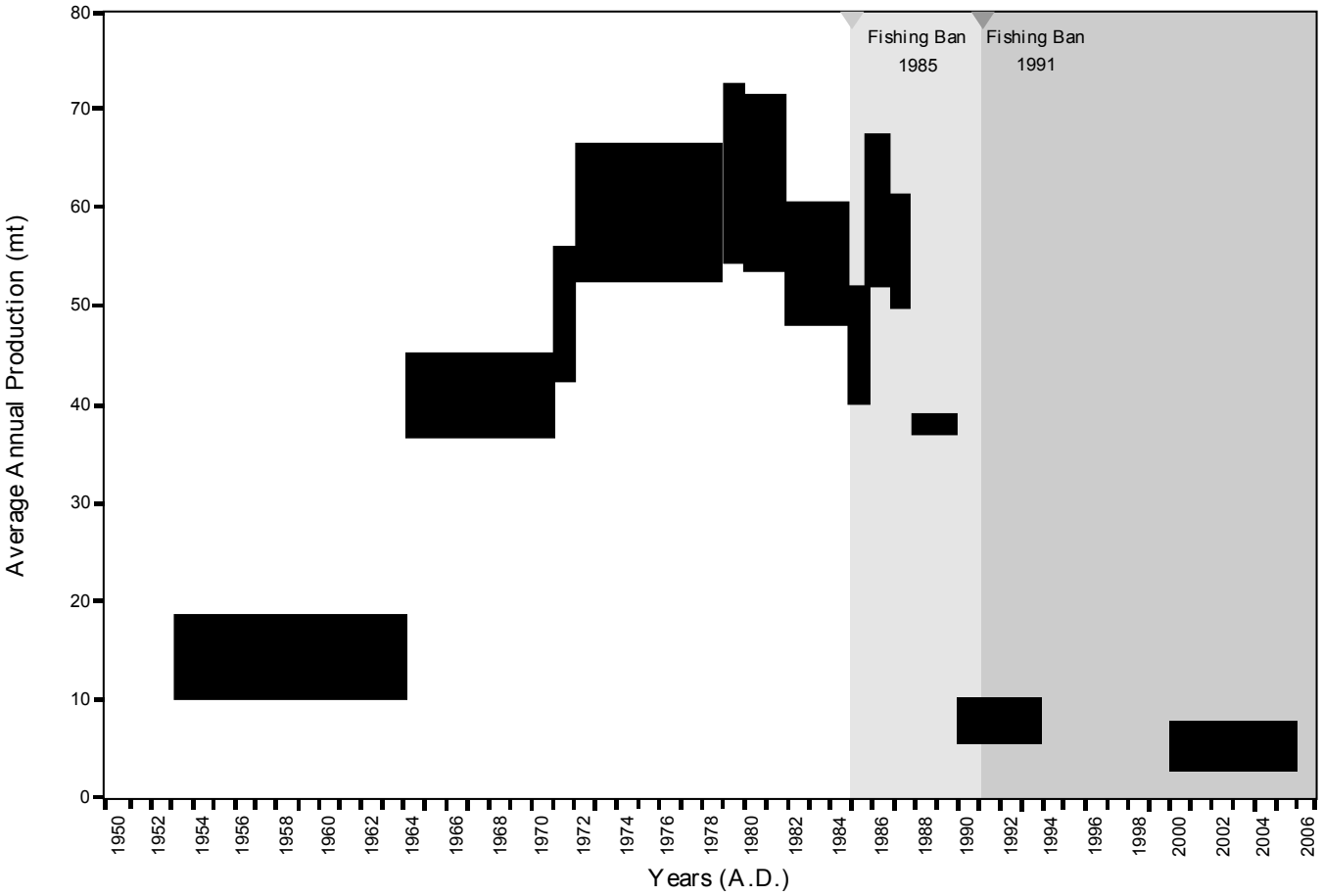

Figure 5. Mean annual production of conch meat (mt) from Los Roques archipelago, estimated from midden volumens and probably time frame of their formation. Black bars represent the 95% confidence intervals. Imposition of fishery bans are indicated (Taken from Posada et al. 2006).

CONCLUSIONS

It is evident from this review that fishery statistics for queen conch ordinarily span just a few decades. While modern fishery records and stock assessments provide the primary basis for current management practices, shell remains can provide valuable historical perspective for both the ecology and exploitation of queen conch in the Caribbean region. Consequently, shell middens should be treated as valuable and irreplaceable research resources, and those surveying the middens need to follow good archaeological practices so that as much information as possible can be extracted. This is particularly important when destructive sampling is required. In such cases, care should be made to preserve information available in the stratigraphy of the middens through precise record-keeping, established photographic techniques, and by using all possible metrics for the shell materials. The latter should include basic shell dimensions plus shell lip thickness when possible (for population age structure). While expensive, the maximum number of radiocarbon dates should be obtained for any middens believed to include shells taken by pre-Columbian fishers. Old middens have already been lost to shoreline movements and development, and there is an urgent need to extract valuable information from these fragile records.

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