Coral Reef Fisheries of the Gulf of Mexico and the Caribbean

Las Pesquerías de los Arrecifes Coralinos del Golfo de México y el Caribe

La Pêche sur les Récifs Coralliens du Golfe du Mexique et dans les Caraïbes

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ABSTRACT

Most fisheries worldwide are exploited intensely, and nearly half of the stocks are overexploited. Over a billion people depend upon coral reef fishes worldwide, which provide US$30 billion in net benefits in good and services, from which fisheries are included. Catch records of the Caribbean and the Gulf of Mexico account for somewhat more than 60 species, but the real number of exploited species surely exceeds one hundred. Unfortunately the great majority of stocks have not been assessed yet. An estimated Maximum Sustainable Yield of the region is 2.65 Million mt, with a biomass of 5.3 Million mt; unfortunately current yield and biomass suggest a 30% reduction. One third of these figures are for the Gulf of Mexico. The main indicators of overexploitation can be identified as mean size reduction of fish caught and gradual decrease in the catch per unit of effort, associated to high fishing pressure. Apart from fishing intensity, climate impacts and pollution on coral reefs are contributing to depletion of exploited stocks. In addition, destructive fishing practices and other activities like tourism, contribute to reduce productivity of the coral reef ecosystem. Therefore, the perspective of coral reef fisheries will be conditioned by the political, social and economic trends and attitudes.

KEY WORDS: Coral reef fisheries, Maximum Sustainable Yield, Gulf of Mexico, Caribbean

INTRODUCTION

The Caribbean basin is the geographic area of the west Atlantic sea defined by a series of islands, from Cuba to the west, extending south on the Mexican Caribbean coast of the Yucatan peninsula, continuing along the Caribbean coast of Central America, and then continues eastward across northern coast of South America, specifically Venezuela and the Caribbean Region of Colombia. It is bounded on the east by the arc of the Antilles archipelago. Bermuda and Bahamas are customarily included within this region, although they are located outside the basin, but they share the cultural and historical heritage of the countries of the West Indies, former British colonies (Figure 1). With the southern Gulf of Mexico, this region holds a profuse development of coral reef ecosystems in a well defined set of tropical ecosystems with high diversity, sharing mangrove swamps, sea grass beds, and coral reefs.

Latin American fisheries, where most Caribbean fisheries are included, have been developed creating a wide diversity of schemes responding to local fisheries contexts, and nstitutional, resource and ecosystem dynamics and governance capacities (Orensanz and Seijo 2013). As a result of these characteristics, many exploited species are shared in all this region; however, there are no catch records for many of them, whose fisheries are of artisanal type and under intense fishing pressure (Munro 1978). No industrial fishing exists in continental shelves, excepting tuna, which is exploited offshore. Therefore, the purpose of this paper is to provide an overview and a dignosis of the stocks based on statistical catch data recorded in FAO (Fishstat) since 1950 to present, in order to define a baseline to help decision-making of the Caribbean coral reef fisheries; these records account to nearly 70 stocks. In many cases, the name of a stock is just a generic way to make reference to a group of species, but despite this aparent defficiency, it is much better to have them grouped rather than an absolute lack of records.

MATERIAL AND METHODS

Based on the FAO catch records, a diagnosis of the fifteen most important fisheries was made. The selection of these fisheries was undertaken after a selection of those stocks strictly associated to coral reefs. Accurate stock assessment of these fisheries in different countries is beyond the scope of this paper, and a description of the trend observed in each case was made; in some cases a clear trend to reach a maximum and then a decrease as consequence of probable overfishing, allowed to draw a trend line suggesting the maximum yield, and the year when it was attained; in other cases, a collapse as result of excessive fishing intensity is perceived. In only one case, the eumetric growth of the fishery is noticeable, but it belongs to a shellfish species probably not strictly linked to coral reefs.

RESULTS

The Main Exploited Shellfish

The examination of catch data indicates that by volume, the main exploited stocks are not strictly depending on coral

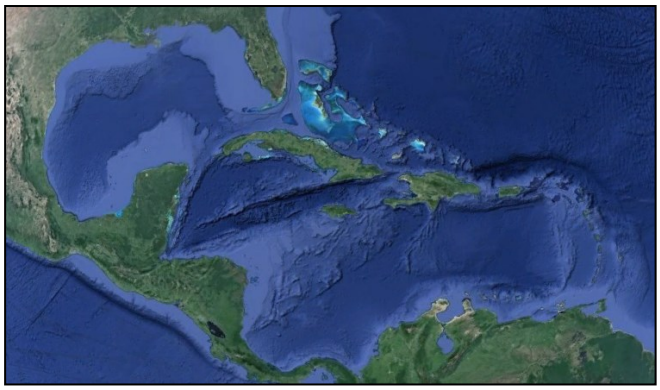

Figure 1. The Gulf of Mexico and the Caribbean Sea.

reefs, they are transient species instead. Many records belong to species which are not part of the coral reef ecosystem, do not depend on coral reefs and belong to migratory species, like sardines, mackerels, a tuna and other species (Figure 2). By looking at Figure 2, three capital letters were added to the species names, which were interpreted from Fish Base after the common name; it seems that in the case of a species of menhaden from the east coast of the USA, (*Brevoortia tyranus*), may be not even a species of tropical distribution. Other species in that figure are well known to be distributed in the tropics.

From the list of exploited shellfish fisheries of the region (Figure 3), it is evident that the coral reefs scarcely contribute with significant volumes: only the spiny lobster from Cuba appears in the main fisheries list, but unfortunately it seems to be severely overexploited as it will be shown ahead. Two other species are in this list, but it is doubtful to assign them as strict dwellers of the coral reef ecosystem, the ark clams from Venezuela, and the octopus

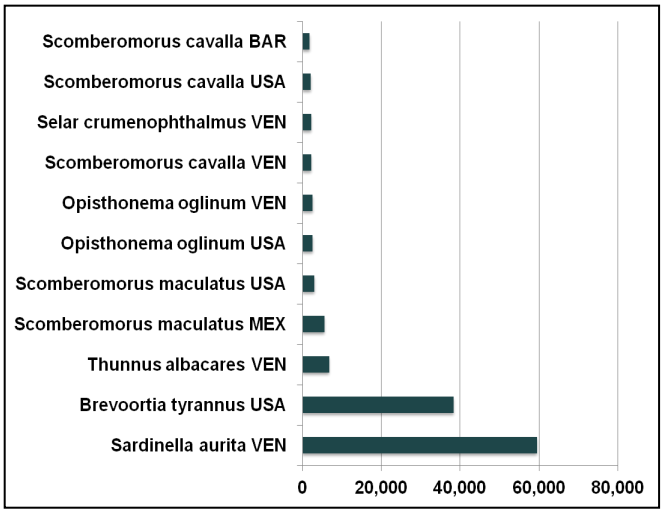

Figure 2. The main Caribbean fisheries are transient species of wide distribution. The reference to each country where catch data are from is indicated by three capital letters after the species name: BAR, Barbados; MEX, Mexico; VEN, Venezuela, and USA, United States. Bars correspond to the average catch of the last ten years (2001-2010). Metric tons.

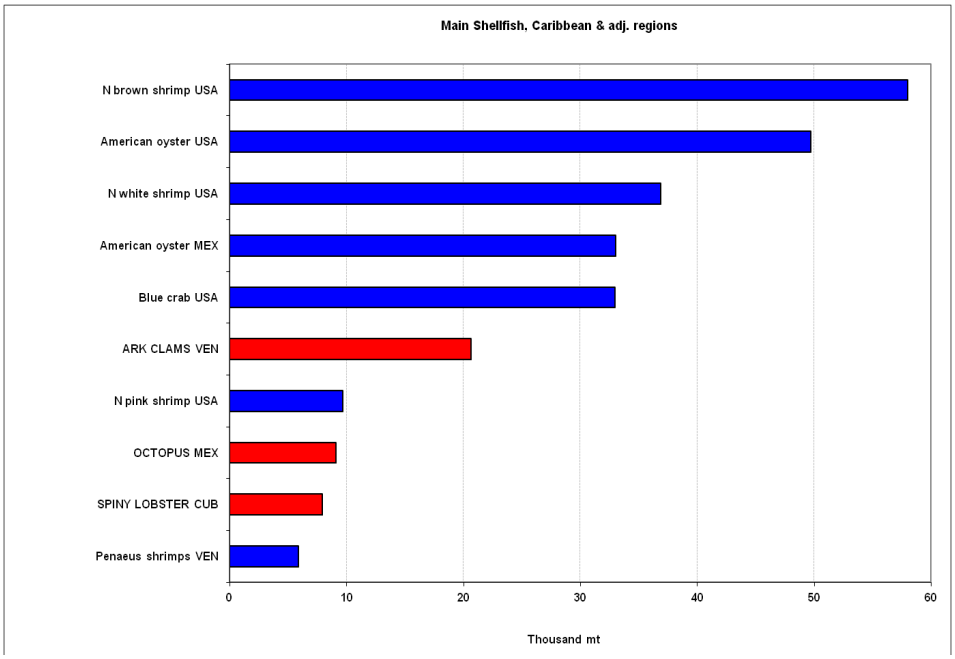

Figure 3. The main Caribbean shellfish fisheries. In this figure, only red bars correspond to coral reef dwelling species, with the possible exception of the octopus from the Campeche bank, which is not neccesarily a coral reef inhabitant. The blue bars belong to species that may use coral reefs as nursery grounds, like shrimp. The American oyster is a brackish-water species. Initials in three capital letters after the name of the fishery indicate the name of country: CUB, Cuba; MEX, Mexico; VEN, Venezuela; and USA, United States.

fishery from the Campeche bank. The remaining seven fisheries evidently are not coral reef dwellers.

By looking historical records of shellfish catch of coral reef species, it is remarkable to realize that, from the whole set of catch records, only two of them are strictly associated to the coral reef ecosystem, the queen conch (*Strombus gigas*) and the spiny lobster (*Panulirus argus*). The main catch of this data series corresponds to the ark clam, which is extracted in high volumes, but despite it occurs in coral reefs, it may be not strictly associated to the coral reef community (Figure 4a).

In order to show the catch data series of coral reef dwellers in more detail, ark clam data were removed from Figure 4a and this way the queen conch and the spiny lobster catches are displayed in Figure 4b. This figure evidences that the main catch volumes belong to the spiny lobster, caught by Cuba and the Bahamas. In third place there is the queen conch exploited in Turks and Caicos, followed by the spiny lobster from Florida and then the same stock from Honduras. The spiny lobster is caught by 25 Caribbean countries, but just a few contribute with significant amounts. This fishery provides job to nearly 30,000 fishermen in the whole Caribbean (Chávez 2007).

Diagnosis of the Status of the Main fisheries

After the overview of the spiny lobster and the queen conch production, it was necessary to do a diagnosis of the status of the fourteen main fisheries, whose list in order of importance, is shown in Figure 5. From here, the importance of the ark clams is remarkable, with over 16,000 mt, followed by the spiny lobster from Cuba and the Bahamas, with over 8,000 mt and 4,000 mt, respectively.

Before proceeding to the diagnosis, it is pertinent to recall the criterion on which the diagnosis was based. For this reason, Figure 6 describes the catch trend as a function of the fishing intensity (the example was taken from Chávez 2007). In that figure, is evident to perceive that as far as the fishing pressure increases, the catch, the profits, the number of boats and fishers, increase up to a certain point, equivalent to the maximum sustainable yield (MSY). Before this point, it is said that the fishery is under exploited and the fishery is in the eumetric stage of development, before the MSY is reached. The MSY level is the catch level in or around the apex of the curve; it is a target chosen for many fisheries worldwide, but it has the inconvenience that when it is attained, the stock can be easily overexploited; for this reason it has been considered as the extreme reference point (García 1996). After the MSY is reached, fisheries are overexploited, and it is usually hard to convince the fishers to reduce fishing effort; for this reason fishing authorities are often forced to aplly coercitive regulations to enforce further reductions in fishing effort and to increase minimum size limits of animals caught.

After these considerations, it is pertinent to mention that in order to diagnose the status of the main shellfish fisheries of the Caribbean, second degree regressions were applied to catch records of the main exploited stocks. Resulting lines are equivalent to the line described by the Schaefer model, but less accurate. However, they provide a guideline for the diagnosis of any fishery, as long as the catch trend describes by itself a dome over time. After all,

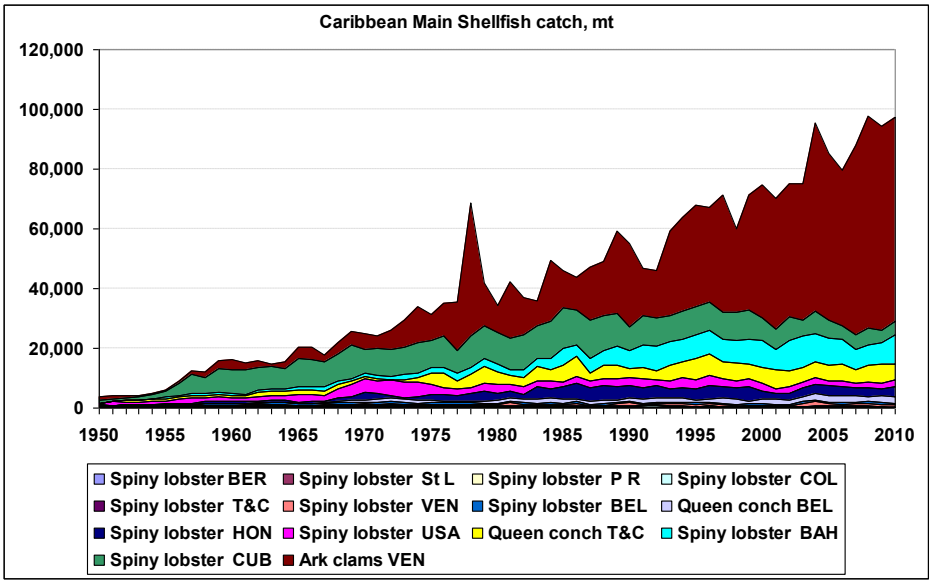

Figure 4a. The main Caribbean shellfish catch over the last sixty years. The reference to each country where catch data belong to, is indicated by three capital letters after the species name: BAH, Bahamas; BAR, Barbados; BEL, Belize; BER, Bermuda; COL, Colombia; CUB, Cuba; HON, Honduras; MEX, Mexico; P R, Puerto Rico; St L, Saint Lucie; VEN, Venezuela; T&C, Turks and Caicos; and USA, United States.

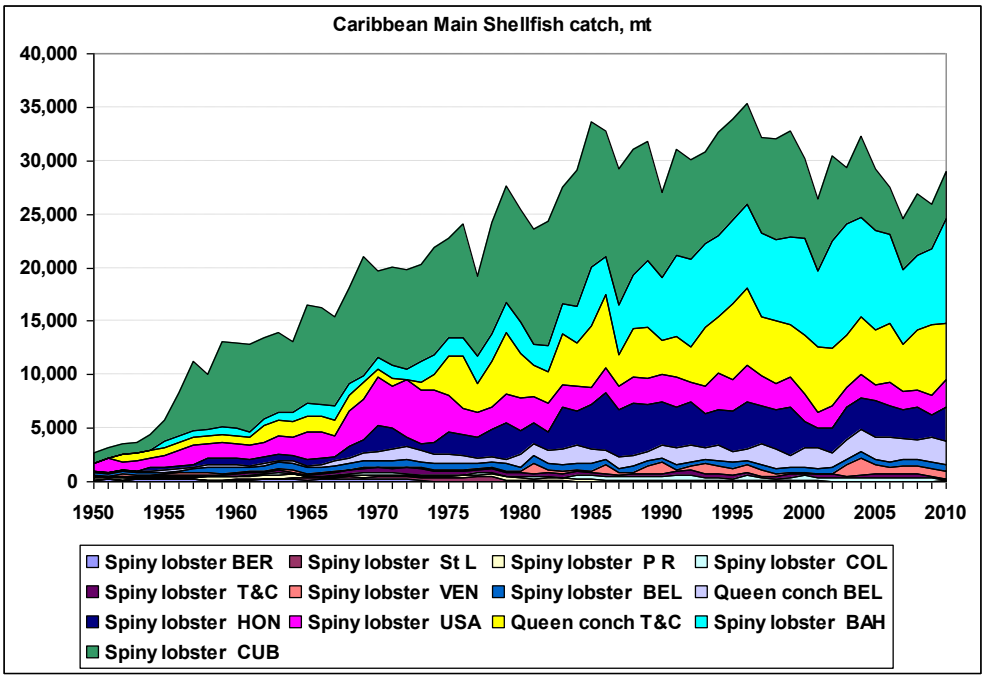

Figure 4b. The main Caribbean shellfish catch. In this figure, the catch of ark clam was removed to show more clearly the trends of spiny lobster and queen conch caught in the region. Initials in three capital letters after the name of the fishery indicate the name of country: BAH, Bahamas; BAR, Barbados; BEL, Belize; BER, Bermuda; COL, Colombia; CUB, Cuba; HON, Honduras; MEX, Mexico; P R, Puerto Rico; St L, Saint Lucie; VEN, Venezuela; T&C, Turks and Caicos; and USA, United States.

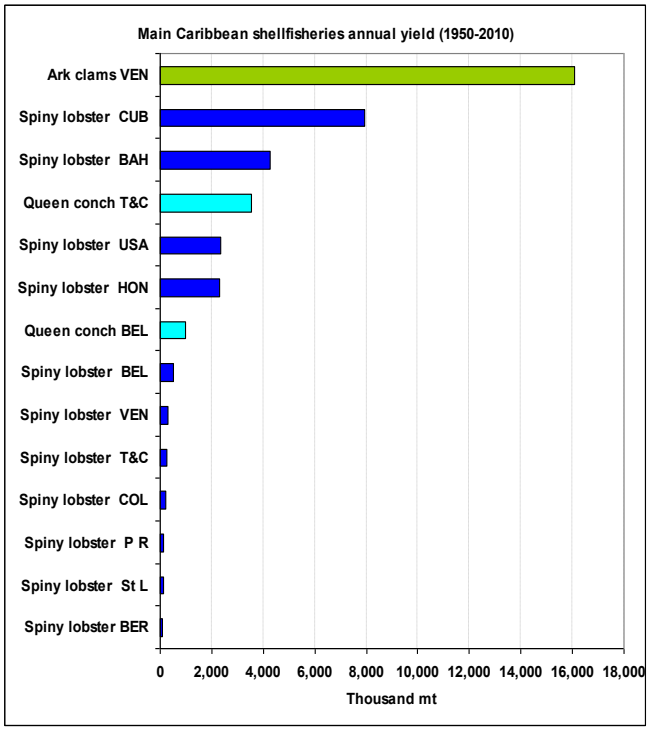

Figure 5. Yield of the main Caribbean shellfish (average of sixty years).

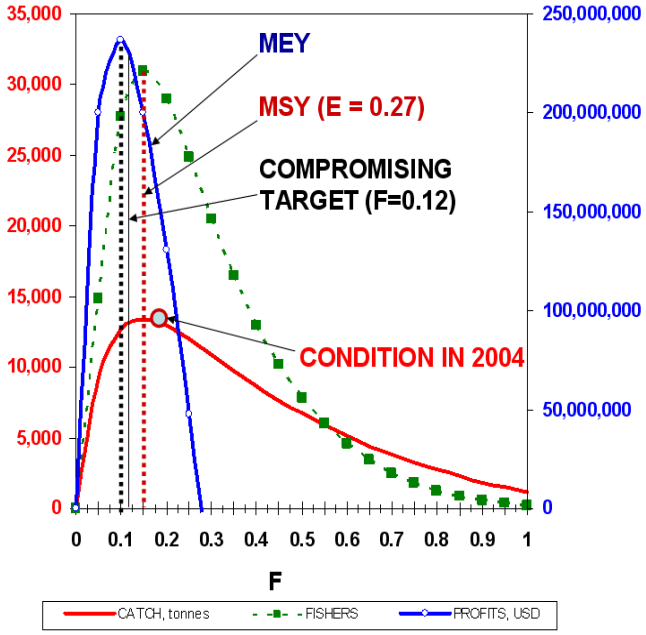

Figure 6. Socio-economic variables as response of a fishery as a function of the fishing intensity. Reference points useful for the management are shown (Redrawn from Chávez 2007). The figure is based in the spiny lobster assessment of all Caribbean fisheries, but the principles that it shows are valid regardless the fishery.

there is a wide degree of uncertainty in all fisheries estimation (Munro 1978), but is true despite the method of evaluation and is a valid premise nowadays .

Then, examination of catch records allowed to diagnose the status of fourteen fisheries belonging to three different species, the spiny lobster, the queen conch, and the ark clams. With one exception, these data were considered in three levels of exploitation: sustainable, over exploited, and depleted fisheries.

In the case of spiny lobster, five countries are exploiting their stocks in a sustainable way, Bahamas, Florida, Belize, Venezuela and Turks and Caicos (Figure 7). In Bahamas and Belize, the exploitation has been maintaining their fisheries in high levels, with 8,000+ mt and 600 mt respectively; however, in the first case, the fishing effort should be carefully constrained to avoid over exploitation of their stocks in the near future, specially in the case of Bahamas. For the cases of Florida, Venezuela, and Turks and Caicos, the same recommendation is valid, although the stocks seem to be under high levels of uncertainty. The florida lobster fishery seems to be quite stable for more than 30 years, which leads to assume that the fishing pressure is under strict control.

Spiny Lobster

Sustainable fisheries — Five countries are exploiting their stocks in a sustainable way, Bahamas, Florida, Belize, Venezuela and Turks and Caicos (Figure 7). In Bahamas and Belize, the exploitation has been maintaining their stocks in high levels, with 8,000 + and 600 mt, respectively; however, in the first case, the fishing effort should be carefully constrained to avoid over exploitation of the stock in the near future, specially in the case of Bahamas. The case of Florida, Venezuela, and Turks and Caicos the same recommendation is valid, although the stocks seem to be under high levels of uncertainty. The florida lobster fishery seems to be quite stable for more than 30 years, which leads to assume that the fishing pressure is under strict control.

Overexploited fisheries — Catch data of three countries suggest that their spiny lobster fisheries have been over exploited for nearly 25 years, as in Cuba, and almost 20 years in Honduras, and more than 10 years in Colombia (Figure 8). This condition of exploitation leads to suggest that a strict control of the fishing effort should be imposed

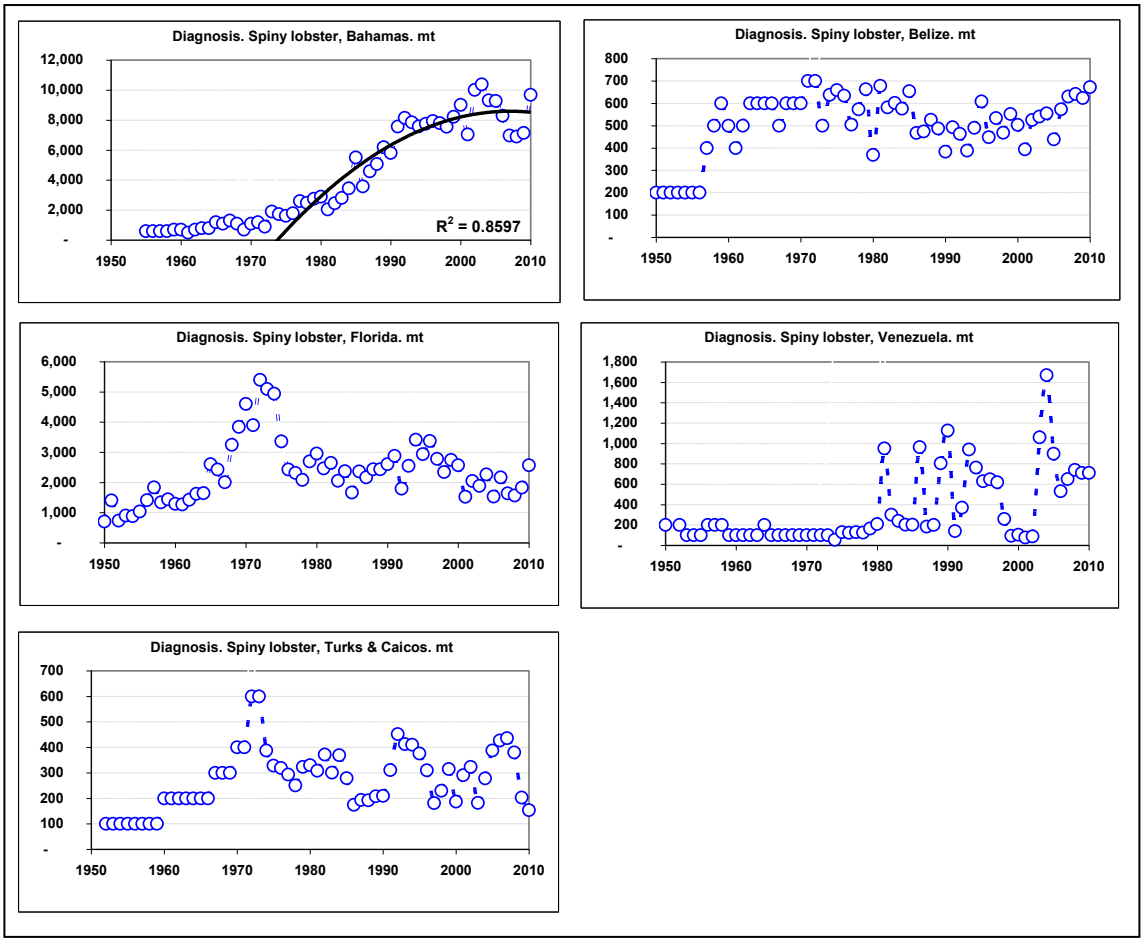

Figure 7. Spiny lobster fisheries which are considered sustainable or at least stable: Bahamas, Florida, Belize, Venezuela, and Turks and Caicos.

to recover the stock biomass, otherwise these fisheries may fall into a collapse in the near future. If the access to the exploitation is controlled, the biomass can be recovered in few years doubling the catch volume, increasing the income and the number of jobs. In current condition, the catch is the half or less than the volumes that were obtained in the past and the loss of the number of jobs has been unavoidable. Fisheries managers should have this in mind in order to do their best effort to restore their fisheries.

Collapsed fisheries — In this group, it is sad to realize that the spiny lobster fisheries have been heavily overexploited, to the point that the fishery as an economic activity, may have disappeared nowadays, as is seen in Figure 9. The advice that is made here is that these fisheries should be closed for at least two years, in order to allow the stocks to be restored.

It is suspected that the spiny lobster fisheries in the fourteen remaining Caribbean countries not described here, may have suffered the same fate; however, statistical information can not allow to diagnose the status of their fisheries.

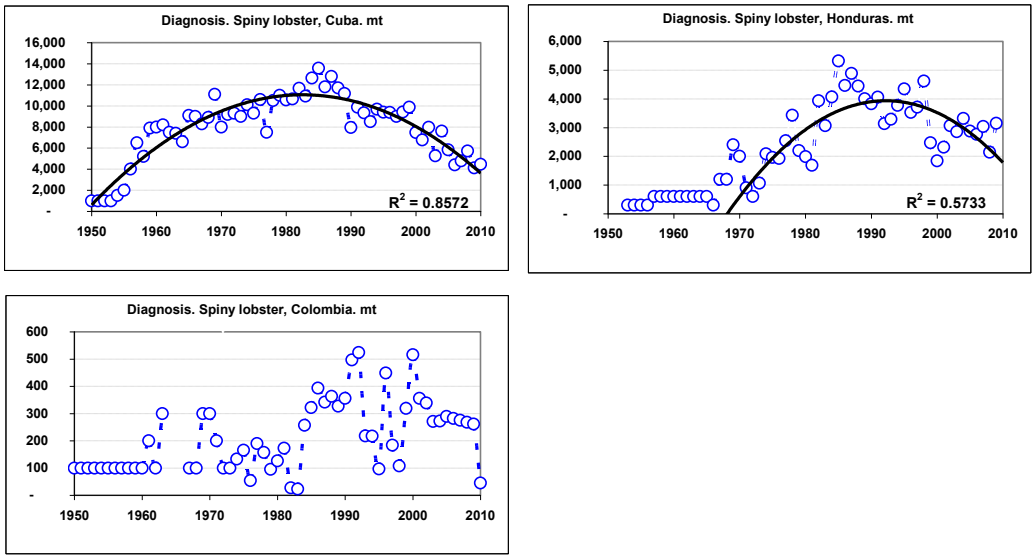

Figure 8. Spiny lobster fisheries which are considered overexploited: Cuba, Honduras, and Colombia. Reduction of fishing effort should be applied to recover the stock biomass.

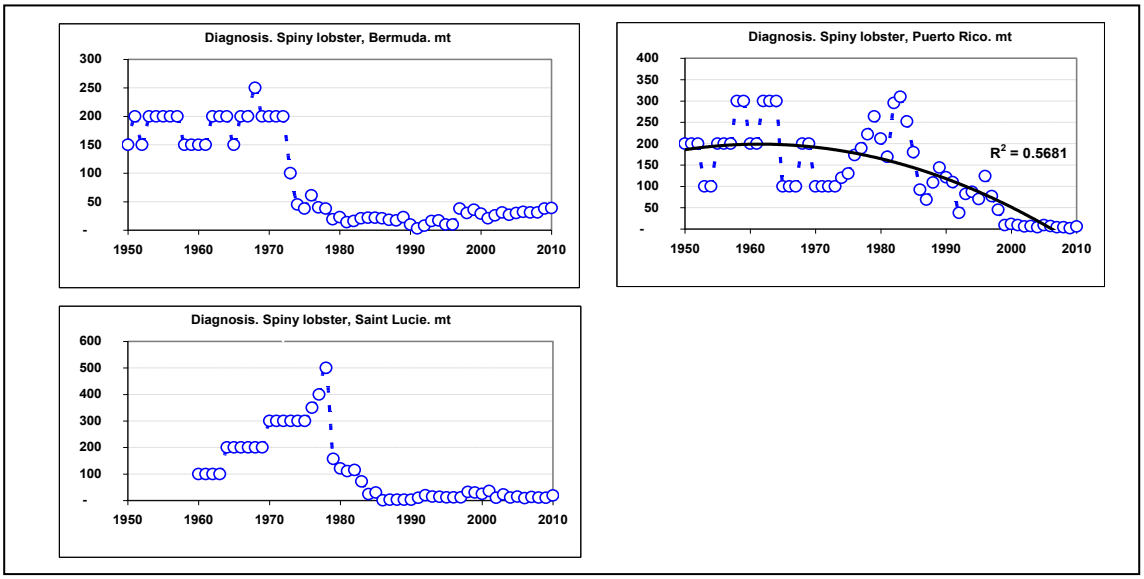

Figure 9. Collapsed spiny lobster fisheries of Bermuda, Puerto Rico, and Saint Lucie. Closing these fisheries for at least two years seem to be the only way to restore the stocks.

Queen Conch

Sustainable fisheries — Statistical catch records of Turks and Caicos and Belize indicate that in these two cases, the queen conch are in a healthy condition, showing a sustainable growing trend. In the case of Turks and Caicos, the production seems to be stabilized in about 6,000 mt, and in Belize, the exploitation seems to be in a eumetric stage, with near 2,500 mt in the last few years Figure 10. The inclusion of this stock into the Cites list suggests that these two countries will not be able to export their product and for this reason will have a surplus production of conch meat which probably will force them to self-consumption.

The Ark Clam (*Arca zebra*) Fishery

The ark clam ((*Arca zebra*) of Venezuela is a special case, its fishery is in eumetric stage (Figure 11) and the trend leads to suspect that this is a stock with short life span and therefore with a high turn-over rate. The last year of catch records, with 70,000 mt, indicates that it has not attained the stabilization level yet.

FINAL CONSIDERATIONS

A planning review council was created to provide guidance for the study of the Gulf of Mexico, induced by the need to understand the effect of oil spill by the Deepwater Horizon Oil Spill. Unfortunately it is focused to the northern Gulf of Mexico. Beaver and Chavez (2007) examined the coral reef fisheries of the southern Gulf of Mexico and more recently, Chávez and Chávez-Hidalgo (2013a) estimate the biomass of the Gulf of México, and that of the world fisheries, including the Caribbean sea (Chávez and Chávez-Hidalgo 2013b), whose estimation indicates a MSY of 2,650,000 mt, with a production of 1,840,000 as average for the years 2008 - 2010, figure that suggests a significant level of overexploitation of nearly 800,000 mt. However, these figures include many species not associated to coral reefs, and to have a more accurate figure, the data from Claro et al. (1994) should be considered, who mention that the Cuban shelf, which is mostly of coral reef nature, produces 1.4 g/m^2. \Coral reefs are very diverse ecosystems, but they have low productivity per unit area. In many coral reefs, their fisheries show symptoms of de-

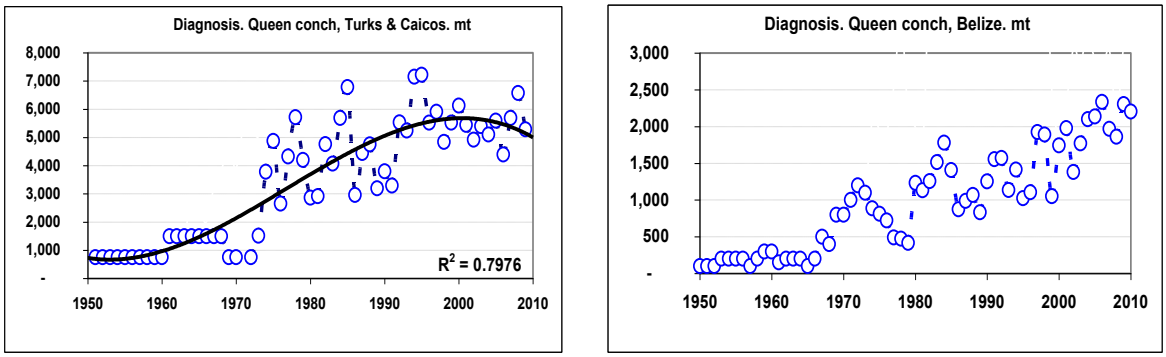

Figure 10. Two queen conch sustainable fisheries, Turks and Caicos and Belize.

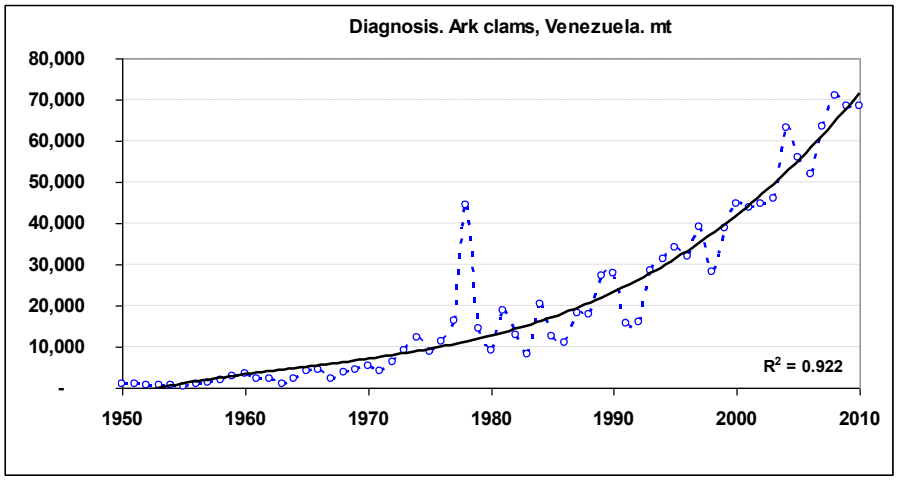

Figure 11. The catch trend of ark clam of Venezuela indicates that this fishey is in a eumetric stage.

pletion. Demographic growth of human population is one of the main causes of depletion of exploited stocks in the Caribbean and anywhere else (Koslow et al. 1988, Chávez and Tunnell 2007).

Managed fisheries ecosystems shift over time in response to evolving environmental as well as market and political factors (Espinoza-Tenorio et al. 2010). However, it is more important that cost-effective management systems be adopted, both in economic terms and in the eyes of the people (Munro and Fakahau 1992), a statement that is intuitively perceived by fishermen.

High biodiversity of coral reefs imposes a challenge to decision making for ecosystem based management of exploited stocks, specially in cases where catch records are unexisting. Catch characteristics such as diversity, trophic level, and body size at landing site were examined along a fishing pressure gradient (Cinner and McClanahan 2006; Cinner et al. 2013), finding that factors such as markets and endogenous factors as fishing pressure that were related to the condition of fish catch affecting the sustainability of local reef fisheries, apart from the climate change effect. This is a problem that is happening along the Caribbean reefs, where the integrity and well-being of coastal fishers, communities, and ecosystems will go a long way to ensure the health of these coastal systems into the future (Charles et al. 2013).

FAO´s catch records are good tools for a first diagnosis. However, further evidences of stock depletion are:

i) Lower catches,
ii) Smaller sizes of animals caught,
iii) Trend to reduce biodiversity, and
iv) Phase changes in the reef ecosystem induced by the scarcity of herbivorous fish (Hughes 1994).

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