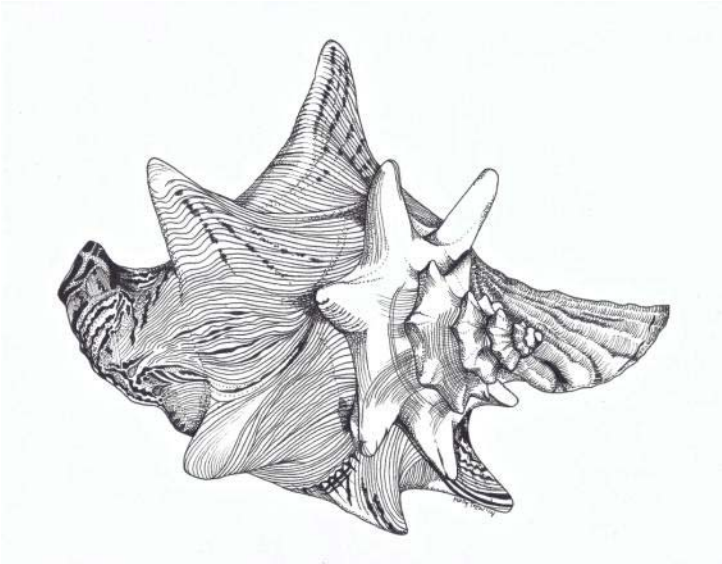
2ND MEETING OF THE CFMC/WECAFC/CITES/OSPESCA/CRFM WORKING GROUP ON QUEEN CONCH

CFMC/WECAFC/OSPESCA/CRFM/CITES



(draft)

REGIONAL QUEEN CONCH FISHERIES MANAGEMENT AND CONSERVATION PLAN

By

Martha C. Prada and Richard S. Appeldoorn

San Juan de Puerto Rico, November, 2014

Table of Contents

List of Figures

List of Tables

1. Introduction

This document proposes guidelines for developing more integrated management actions in the Wider Caribbean for the queen conch (*Strombus gigas*), a species listed in CITES Appendix II, that are required for its sustainable use and conservation.

This large herbivorous mollusk is considered perhaps one of the most beloved species in the region, deeply immersed in Caribbean culture of several countries. Conch life cycle is developed through several habits from shallow water to potentially up to 50-80m deep. Its fishery accommodates more than 20.000 fishers in the Caribbean region, and represents an important activity as it provides employment and income in remote coastal communities, contributes to export earnings as well as to food security and poverty alleviation. The species plays an important ecosystem role. The queen conch fishery is frequently combined with the spiny lobster fishery, since diving is the main fishing technique utilized for both their extraction.

Due to the biological complexity of the species, the lack of good time series of catch and effort data, the lack of regular conch surveys and illegal fishing among other concerns, the status of the queen conch stocks cannot be estimated well at the regional level. There are areas where stocks appear abundant and well managed, but in other areas stocks are depleted and in need of rehabilitation plans. Fisheries management and conservation actions are required at national and regional levels to ensure that the Queen Conch stocks can be sustainable and be utilized also by future generations.

Strengthening managers' capacity, use of best-practices, application of precautionary principles, and promotion of participation by stakeholders is needed for long-term governance of the queen conch fisheries. Any fishery management and conservation plan requires to be adaptive, allowing reconsideration of goals and measures when new scientific and fisheries information becomes available.

This regional fishery management and conservation plan is a developed based on the recommendations of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM working group on queen conch held in Panama last 23–25 October 2012. It is an initiative funded by the Food and Agriculture Organization of the United Nations, its Western Central Atlantic Fishery Commission (WECAFC) and the Caribbean Fisheries Management Council (CFMC) and accounts with the support from the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). It is developed in partnership with the Caribbean Fisheries Regional Mechanism (CRFM) and the Central American Fisheries and Aquaculture Organization (OSPESCA). The 10-years Strategic Plan for the Sustainable Management of the Sharing Living Marine Resources of the Caribbean Large Marine Ecosystem and Adjacent Regions (CLME+SAP) stated in strategy 4B, the need for enhance governance arrangements for implementing an ecosystem approach for the queen conch fisheries, including linkages with organization working on environmental protection of reefs and associated ecosystems.

2. Acronyms

ACP	Group of African, Caribbean and Pacific Nations
ACS	Association of Caribbean States
CARIFORUM	Caribbean Forum for the European Union Agreement
CFMC	Caribbean Fisheries Management Council
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLME	Caribbean Large Marine Ecosystem
CRFM	Caribbean Regional Fisheries Mechanism
IUU	Illegal, Unreported and Unregulated fishing
OLDEPESCA	Latin American Organization for Fisheries Development
OECS	Organization of Eastern Caribbean States
OSPESCA	Central American Fisheries and Aquaculture Organization
QCEW	Queen Conch Expert Workshop
SPAW	Specially Protected Areas and Wildlife
UNEP	United Nations Environment Programme
VMS	Vessel Monitoring System
WECAFC	Western Central Atlantic Fishery Commission
WCMC	World Conservation Monitoring Center

3. Definitions

Conch survey: A field work campaign for direct observation and quantification of the natural queen conch population, which can be done by diving or underwater video-camera systems. Allows for estimation of conch morphometrics, estimation of the conch abundance, size/age structure and determination of sustainable fishable conch biomass.

Control rules: Management decisions and actions (catch/effort decision rules) that define whether the catch levels that are currently being taken, or the effort levels used by each of the relevant fisheries are consistent with meeting the appropriate catch levels as defined by the Harvest Control Guidelines. These specifications are normally contained in national fisheries legislation and other arrangements that might be nationally, sub-regionally, or regionally agreed.

Fisheries management: The integrated process of information gathering, analysis, planning, consultation, decision-making, resource allocation, formulation and implementation that is followed by the enforcement of rules which govern all fisheries activities in order to ensure the continued productivity of the resources.

Fisheries co-management: Management arrangement whereby government and the user groups share responsibility for the management and utilization of fisheries resources, with the goal of achieving a balance between economic and social goals, within the framework of preserving the ecosystem and fisheries resources (Sen and Nielsen, 1996).

Enforcement: Personnel and mechanism(s) available to enforce and ensure compliance of fishery regulations. It involve a broad suite of stakeholders, including administrative personnel and the judicial system, in addition to armed field personnel.

Harvest strategy: Management actions needed to achieve defined biological and economic objectives for a single or group of stocks. These include the use control rules that regulate the level of fishing activity, and the monitoring and assessment processes to inform both setting and progress of the harvest strategy objectives.

Legal acquisition: Conclusion that a CITES specimen was legally obtained. Necessary for all exports.

Monitoring system: the collection, measurement and analysis of fishing activity including, but not limited to: catch, species composition, fishing effort, bycatch, discards, area of operations, etc. This information is primary data that fisheries managers use to arrive at management decisions. If this information is unavailable, inaccurate or incomplete, managers will be handicapped in developing and implementing management measures.

Non-detriment Findings: Conclusion that an export will not be detrimental to the survival of the species. Necessary for all exports.

Population reference points: A (management) reference point is an estimated value derived from an agreed scientific procedure and an agreed model to which corresponds a state of the resource and of the fishery and which can be used as a guide for fisheries management.

Precautionary principles: A set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resources, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong.

Regional: In this document the word "regional" is refers to the Wider Caribbean Region, which consist of the insular and coastal States and Territories that boarder the Caribbean Sea, Gulf of Mexico, and Western Central Atlantic Ocean and that have, had or potential could have natural populations of queen conch. The region includes 28 island and continental countries.

Queen conch: Large marine gastropod of the Strombidae family with the scientific name *Strombus gigas*. Current suggested synonyms for *Strombus gigas* include *Lobatus gigas* and *Eustrombus gigas*. Resolution of nomenclature issues await more detailed studies.

Sub-regional: This refers to a set of countries, typically contiguous, within the Wider Caribbean region selected on the basis of shared criteria, which could be based, for example, on governance, cultural, biological or physical oceanographic characteristics. *e.g.* Central America, Lesser Antilles.

Surveillance: involves the regulation and supervision of fishing activity to ensure that national legislation and terms, conditions of access, and management measures are observed. This activity is critical to ensure that resources are not over exploited, poaching is minimized and management arrangements are implemented.

Sustainable development: The management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Such sustainable development conserves (land,) water, plants and (animal) genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable.

Sustainable Fishing: The rate of harvest that does not result in a decline in the natural population over time due to the fishing practices. Sustainability in fisheries combines theoretical concepts of population dynamics, such at maximum sustainable yield, $F_{.1}$, or Spawning potential ratio, with practical fishery regulations that control fishing effort to avoid overfishing.

4. Background

The queen conch (*Strombus gigas*) is a large gastropod mollusk, endemic to the Caribbean and utilized across its range from pre-Colombian times, and therefore it is both an important fishery resource and closely related to the Caribbean culture. The Caribbean Sea is a semi-enclosed ocean basin (2.6 million km^2), the second largest sea in the world (Bjorn 1997, Sheppard 2000), surrounded by 26 countries and 45 state entities, and several ethnicities and languages. Indeed, the Caribbean Sea is characterized by the sharing of highly diverse marine living resources, which thus demands regional management arrangements to promote their sustainable use.

Caracol rosa, caracol reina, caracol pala, lambi, carrucho, botuto, guarura, cambombia, cambute, queen conch, pink conch or giant conch are all common names for this iconic and transboundary species that inhabits shallow or deep seagrass, algal plains, sandy, rubble or reef habitats depending on its life history stage.

Divers can capture conchs easily by hand because they move slowly, form big aggregations and have few defense mechanisms. Conch divers can operate with or without the support of a larger vessel for transport and pre-processing (Figure 1). Conch fishing is done from a very small scale (subsistence) to large commercial scale (several tons). As abundance decreases, conchs appear to refuge in deeper waters (Weil and Laughlin 1984, Glazer and Kidney 2004, Lovell 2012) inducing divers to go further and use Scuba more regularly. In this way, fishing can frequently quickly deplete fishing grounds, leading to reductions in their spawning potential and affecting recruitment capabilities over the long-term. This species may have low resilience to high fishing mortality (Appeldoorn et al., 2011), and once depleted it may not recover easily.

Despite the difficulties in getting appropriate and updated estimations of total landings, it is believed that regional annual conch production is around 7,600mt. The Conch Fisheries provides income for around 20,000 fishermen, and is an important and traditional source of low fat protein for the Caribbean population and caters also to millions of tourists that visit the Caribbean annually. Accordingly to FAO/WECAF/COPACO/CFMC (2012), the overall value of the fishery is estimated to be around $60 million (US). The economic importance of the conch fishery is highly variable across the region. For instance, in Jamaica, it represents the most important fishery, but in areas with limited shelf, such as Barbados and St. Lucia, it does not represent more than 2% of their total fishing production. Approximately 60% of the queen conch production is exported to the US/EU markets, 29% is exported within the French West Indies (UNEP-WCMC CITES Trade database 2010-2011), with approximately 21% used for local consumption.

Figure 1. Photographs illustrations the great variability oh how the queen conch fishery operates.

Photos by: Stephen Smilke, Martha Prada, Oscar Ortegón, Reinaldi Barnutty, Jose Antonio Romero, and Martha Inés Garcia.

Because determination of conch abundance in deeper waters is difficult, and complete and historical catch and effort data are not available, the status of the stocks in the region is unknown or at least highly uncertain (MRAG 2013). On the other hand, conchs cannot be aged, and appear to have a highly variable mortality throughout their lifecycle, two biological characteristics that limit the application of traditional stock assessments methods. These high population risks and high international demand set the basis for the inclusion of this species in the Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), as a way to promote its conservation and sound management across the region. The CITES Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. International trade in specimens of Appendix-II species may be authorized by the granting of an export permit or re-export certificate. The species was listed in CITES since 1992, but the majority of countries did not become party to the convention until years after that. Compliance with the CITES listing generally has been good, although some countries have been quicker to respond than others (MRAG 2013).

The species was also listed in Annex III of the Specially Protected Areas and Wildlife (SPAW) protocol (2000) of the Cartagena Convention, which allows harvesting of listed species but encourages member states to “adopt appropriate measures to ensure the

protection and recovery of the species…and regulate [their] use…in order to ensure and maintain their populations at the highest possible levels" (UNEP 1990, Art. 11 (1c)).

In recent years, national efforts for the management and conservation of queen conch have increased in the region, encouraging managers to improve understanding of the species's ecology and management needs, and be able to enhance enforcement to combat illegal catch and trade. For instance, the developing of a common fisheries policy in SICA countries (OSPESCA 2009) and a Memorandum of Understanding and Plan of Action in 2012 between CRFM and OSPESCA and tackling illegal fishing in the CARICOM region (Castries Declaration 2010) and the SICA region (Regulation OSP 08 2014, OSPESCA 2012), which, while not specific to conch, point to initiatives that would benefit queen conch fishery management.

With the completion of two Caribbean ACP Fish II Projects awarded through the CARIFORUM/Caribbean Fisheries Regional Mechanism (CRFM) on queen conch in 2013, there have been advances in case studies, recommendations for harmonized management actions, and regional training in underwater visual conch census, which constitute significant contributions towards regional management and capacity building.

However, the use of the precautionary approach is still required when looking for regional management actions. Given that conch fisheries are believed to be fully developed in most areas, and the increasing levels of illegal fishing, this precautionary approach might include the application of control rules, which in the end would represent a reduction in fishing effort and demand compromises from all the different associated sectors, including national and international stakeholders and traders.

WECAFC is the only umbrella organization that covers the entire set of Caribbean countries and territories, with CRFM, OSPESCA acting as sub-regional organizations. The regional involvement of the Caribbean Fisheries Management Council, in particular dealing with the queen conch management issues, has been relevant and accepted throughout the Wider Caribbean. Complementarily, the CITES role has been key in regards to promoting sustainable use and exports targets for the species. This complexity in regional conch fisheries management not only reflects the number of countries and management organizations involved, but also illustrates the degree of coordination needed to avoid duplication efforts, and in general enhance overall ocean governance.

4.1. Description of the resource

The queen conch is distributed across the wider Caribbean, with Bermuda at the northern most edge of the species' distribution, Panama at the south-western most, Barbados at the eastern edge (Figure 2). Most islands located between these extremes have reported queen conch production.

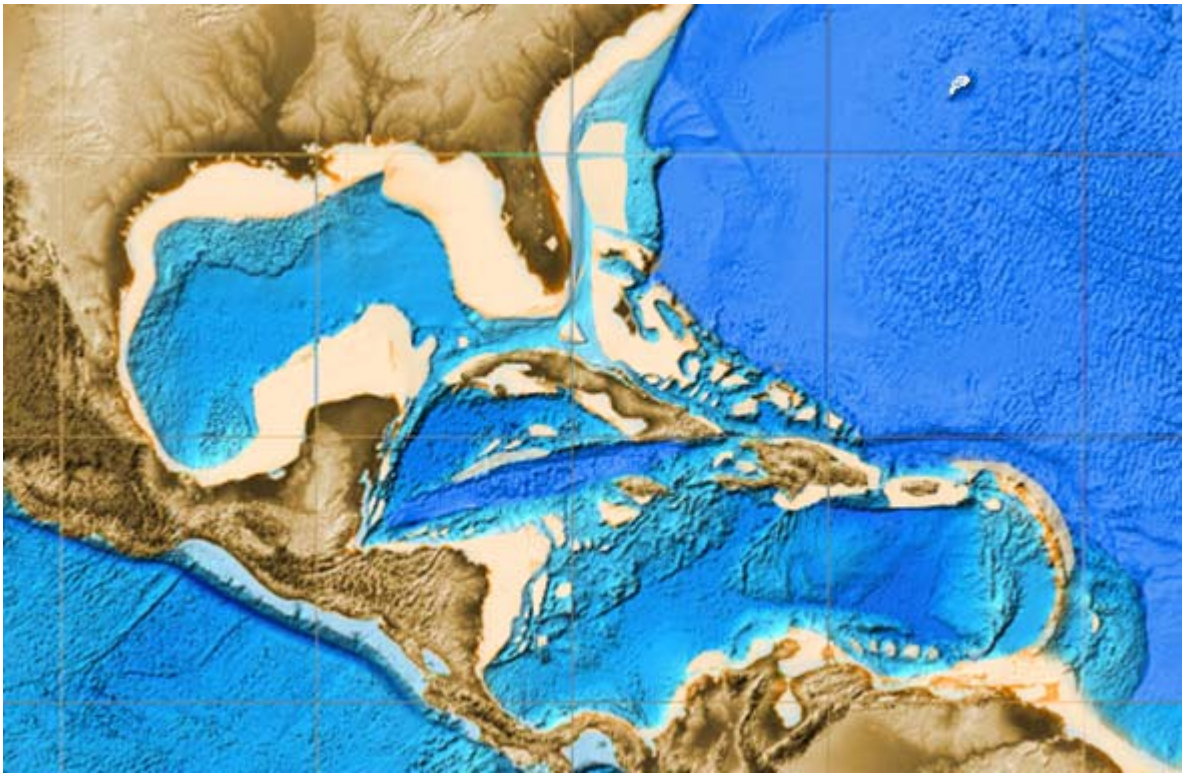


Figure 2. Queen conch distribution in the Wider Caribbean (highlighted).
Based on map from NOAA National Geophysical Data Center (http://maps.ngdc.noaa.gov/viewers/bathymetry/). Taken from SOFRECO 2013.

Shells can vary substantially in size due to habitat and geographic nuances. Males and females are distinguished by either a verge or egg grove, which can be observed once the meat is extracted from the shell. Reproduction occurs during the warmer months (28-28°C), but exact timing can vary depending on location and annual variations in temperature. Conch do not reach sexual maturity until the shell is large (usually ≥200mm total length) and the shell lip is fully developed (12-26mm thick) approximately at the age of 3-4 years.

Different conch life stages occupy different habitats extending over a broad depth spectrum (Figure 3). Veliger larvae can be found in surface waters, but approach the sea floor when ready to settle. Early juveniles (usually first year class) are found buried in coarse sandy habitats, near to reefs and seagrass beds (Robertson 1959, Randall 1964, D'Asaro 1965, Brownell 1977, Weil and Laughlin 1984, Sandt and Stoner 1992). Extensive fieldwork in Colombia identified the back-reef, the adjacent lagoon, and the deeper leeward pre-reef terrace as juvenile nursery habitats (Prada et al. 2009). These structural habitats provide both nutrition and protection from predators (Ray and Stoner 1995; Stoner and Davis 2010). Adults prefer sandy algal flats but can also be found on gravel, hard bottom rubble, rodoliths, smooth hard coral or beach rock bottoms (Torres-Rosado 1987; CFMC 1996a; Acosta 2001; Stoner and Davis 2010). When reproducing, conch prefer coarse sand substrates (Glazer and Kidney 2004). Older adults can be found in coral

and sand-patch habitats as well as the deeper leeward reefs. The effects on current flow of major cuts through the forereef are believed to favor larval retention and deposition (Appeldoorn et al. 2003). Adult queen conch are rarely, if ever, found on soft bottoms composed of silt and/or mud, as well as areas with high coral cover (Acosta 2006).

Figure 3. Queen conch habitats through ontogeny.
Photos by: Harvey Robinson, Felipe Cabezas, Heins Bent, Martha Prada, Barbara Reveles, Ricardo Morris.

In general, conchs show a progressive movement away from inshore nursery areas, towards deeper habitats as they increase in size and age. Nursery areas are usually very shallow (less than 5m), while mature and old individuals are progressively deeper and potentially can extend down to mesophotic depths up to 59m (Stoner and Schwarte 1994; Garcia-Sais et al. 2012; Appeldoorn pers. obs.). It is believed depth limitation is based mostly on light attenuation limiting their photosynthetic food source (Randall 1964).

The queen conch has two life stages: one planktonic stage comprised of microscopic, free-swimming larvae, followed by a benthic stage associated with the seafloor (Figure 4). The planktonic cycle begins with the hatching of larvae from a crescent-shaped egg mass laid by adult females. Each egg mass contains from 400,000-1,500,000 eggs (Mianmanus 1988, Davis 1998, Appeldoorn 1997). Egg masses are camouflaged with sand grains to aid survival through the three to four day incubation period. It is estimated, that a reproductive female can lay 7-13 egg masses per season. Females can store eggs for up to several weeks before laying an egg mass, so it is very possible that multiple males have fertilized the same egg mass (Medley 2008).

The conch larvae or veliger emerges 3-5 days after spawning, and develops a velum with progressively multiple lobes, and a transparent shell with one and a half whorls (Stoner et al. 1992, Davis 1998). The veligers stay in the plankton approximately 18-60 days and undergo metamorphosis probably in response to chemical cues exuded from red algae (Mianmanus 1988, Davis et al. 1990, Rodriguez Gil 1995, Brito et al. 2006).

Early juveniles are 3-4mm Siphonal Length (SL), usually buried but potentially emerging at night to feed. Progressively, the shell grows as its body grows bigger, becoming hard and thick. When the conch becomes an adult (i.e., at sexual maturation), it is about three and a half to four years old (Egan 1985, Appeldoorn 1988, Appeldoorn et al. 1997, Stoner & Sandt 1992, de Jesus-Navarrete and Aldama 2000, Stoner et al. 2012). At this age, the shell is approximately 22cm SL but this size varies greatly and may be dependent on environmental conditions. Recent studies have found that sexual maturity in queen conch does not occur until shell lip thickness reaches 8 to 26 mm (Egan 1985, Aldana-Aranda and Frenkiel 2005, Avila-Poveda & Baqueiro-Cárdenas 2006, Stoner et al. 2012).

The length of the shell actually stops growing at sexual maturity and the spines become blunt and worn, while additional shell deposition is dedicated to increasing lip thickness (Berg 1976, Appeldoorn 1988, de Jesús-Navarrete 1997). Experimental studies showed that, for a given shell length, fecundity increases with age, at least until internal shell volume becomes limiting (Appeldoorn 1997). Similarly, recent studies in The Bahamas indicated that large conchs would have higher reproductive potential than smaller individuals (Stoner et al. 2012). It is believed that conch can live to around 20 years or more.

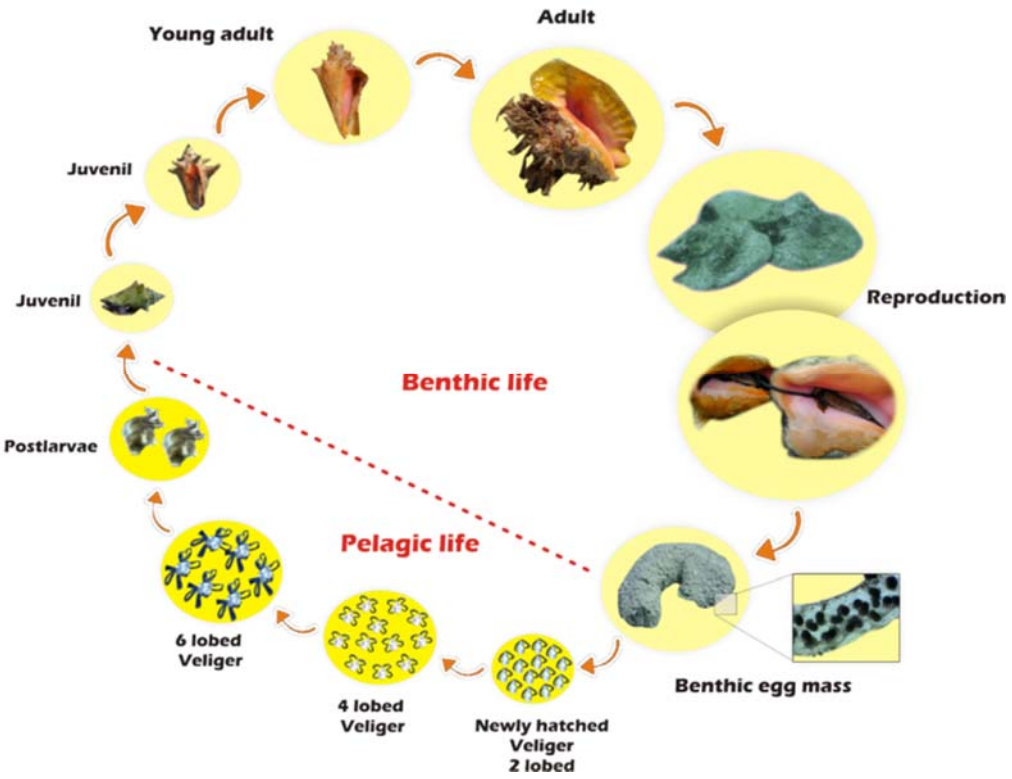
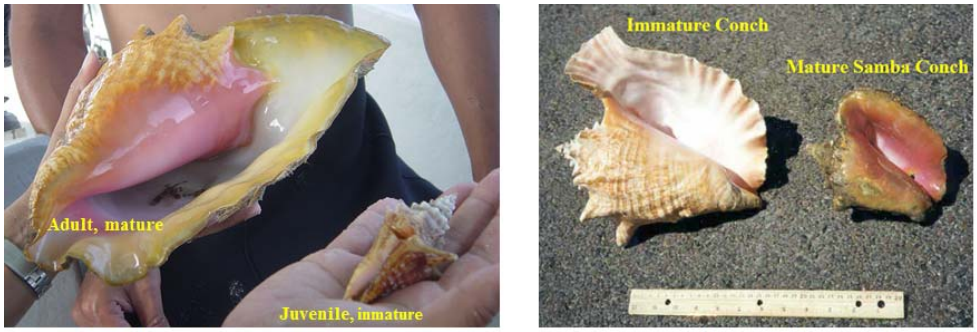


Figure 4. Queen conch life cycle. Taken from SOFRECO 2013.

Conchs form reproductive aggregations to spawn, usually in deeper water (20-45 m) (Frenkiel et al. 2009, Reynal & Aldana 2009), however, under fishing pressure conch reproduction in many areas may be greatly affected by low densities, succumbing to the Allee effect. Stoner and Ray-Culp (2000) reported how conch reproduction is negligible at densities below 50/ha. The relationship of density to probability of successful mating varies in different locations and depends on the level of fishing pressure and how density is measured. A density value of 100 adults/ha within the spawning area was recommended as a reference point to incorporate precautionary principle for successful reproduction, following advice from the queen conch expert workshop held in Miami last May 2012.

The annual reproductive cycle of *S. gigas* can be variable in space and time across the Wider Caribbean, with temperature being an important factor controlling gametogenesis (Aldana et al. 2014). In warm years actual spawning can occur year round while in other years it can by quite seasonal (e.g., Randall 1964, Weil and Laughlin 1984, Stoner et al. 1992, Appeldoorn 1997). Most areas show a marked seasonal peak during the warmest months, usually July-September (Aldana et al. 2014). With recent temperature increases, presumably a consequence of global climate change, it has been suggested that peak spawning may be shifting or expanding into October (Appeldoorn et al. 2011). Conchs have been known to not spawn when under poor environmental conditions (McCarthy et al. 2002), and high density can reduce overall fecundity (Appeldoorn 1997).

Growth rates and morphologies can vary depending on sex, depth, latitude, available food, age class and shelter. In heavily fished sites, large conchs disappear rapidly leading to the dominance of small individuals, thereby influencing the overall conch growth patterns of the population (Borrell 2013). Very old adults are characterized by eroded spines, a very thick and eroded lip, darker meat and the shell covered with sessile invertebrates. These conchs are usually found in deeper waters. It is believed that the meat from these individuals is tougher compared to other conchs. Conchs of different morphology are often given different names by fishermen (Figure 5). For example, the very old large conch on Pedro Bank, Jamaica, are called stoned conch. However, very old and small adults are commonly known as samba conch in such places as Belize and The Bahamas.



Typical growth morphometry | Variation in the growth morphometry

Figure 5. Variability in the queen growth morphometry.
Photos by: Leonardo Arango and Nelson Ehrhardt.

The growth of queen conch has also been shown to be density dependent. As the density of conch in a given area increases, the growth rate decreases. The conch at high densities also had low gut fullness indices and a general low overall condition (Stoner 1989b). It is possible that small-sized stocks living in shallow and unconsolidated substratum will be affected by its potentially lower food concentrations or by the competition in cases of high-density conch populations (Alcolado 1976, Martin-Mora et al 1995).

The relative long-lived larvae dispersed by surface oceanic currents suggest extensive gene flow. However, recent studies using allozymes have revealed the opposite, showing genetic structure either at isolated sites or at micro-scales for queen conch populations in Bermuda, Alacranes reef in Yucatán Peninsula, Gros Islet and Vieux Fort in St. Lucia Island, Turks and Caicos, Grenadines, and St. Kitts and Nevis (Mitton et al. 1989, Campton et al. 1992, Tello-Cetina et al. 2005). Marquez et al. (2013) using microsatellite techniques found four genetic stocks reflecting heterogeneous spatial mosaics of marine dispersion between the San Andres archipelago and the Colombian coastal areas, an area with strong oceanic conditions and permanent eddies (Richardson 2005). Conch exhibited a global deficit of heterozigosity, which was related to assortative mating or inbreeding leading to a potential loss in genetic variation, particularly in those banks with the lowest queen conch population densities (Marquez et al. 2012).

The geographic isolation and limited larvae recruitment may contribute to the lack of recovery in some areas such as Bermuda, where conchs at the limit of their distribution, or Florida, which receives only occasional influxes of larvae via the Florida Current. The small spawning stock in Florida is not thought to be able to produce the amount of late stage larvae observed at these times (Stoner et al. 1996, Hawtof et al. 1998). It is believed queen conch larvae from Belize, Mexico, and Honduras are the upstream sources of conch located in Florida based on the amount of late stage larvae present there (Stoner et al. 1997). Under this scenario, locally produced larvae would significantly contribute to conch population stability (Delgado et al. 2008, Glazer and Delgado 2012).

In summary, more than two decades of research have indicated the shell length or shell thickness are two measurements useful for discriminating adult and juvenile conch and calculating growth. Observations of growth rates, juvenile and adult ratios, and reproductive activity, especially in relation to adult densities, form the biological basis for making scientific recommendations toward the sustainable harvest of queen conch. Unfortunately, populations in heavily fished areas do not always meet the recommended criteria necessary for reproduction and sustainability (Appeldoorn 1994, Clerveaux et al. 2005, Stoner at al 2012, Cala et al. 2012, Aldana et al. 2014).

Variations in queen conch growth can be attributed either to genetic (heritable traits) or phenotypic (physiologic response to local conditions) factors. Currently, there is no consensus regarding the proportion that each factor influences queen conch growth at the population level. Patchy larval settlement may lead to distinct genetic populations, but environmental conditions in different areas are also associated with significant variations in growth and morphology. Therefore, sustainable regional fisheries management would

need to incorporate to some degree the complex biological, spatial and fisheries characteristics of queen conch.

Based on the biology and ecology of queen conch, Appeldoorn et al. (2011) identified several unique aspects critical to maintaining an ecosystem-based approach to management. Most important of these was density, which is closely related to reproductive potential. Other areas of concern were nursery areas, larval dispersal and population connectivity, habitat quality and anthropogenic impacts, and the vulnerability of conch to exploitation. As a consequence, they recommended that management plans incorporate the following: protection of nearshore habitats, juveniles and spawning adults, establish marine reserves in juvenile and adult habitat, and routine monitoring of fishery activity (including spatial distribution) and the underlying population status and distribution.

4.2. Description of the fishery

The main commodity in trade is the white conch meat, a product that have decline over time (Figure 6). These reductions can be attributed partially to overfishing, with some stocks have collapsed and yet to recover (Appeldoorn 1994, Theile 2001, Pérez-Pérez and Aldana Aranda 2003). In other cases, *e.g.*, Pedro Bank (Jamaica), and Serrana Bank(Colombia) large reductions in catch were brought about by aggressive management action to maintain sustainability. Declines in conch landings resulted also from the temporary moratoria on trade from Honduras, Dominican Republic and Haiti imposed under the second CITES Significant Review process in 2003. Grenada and Haiti were previously suspended, during the first CITES review in 1995. Accordingly, with CITES Notification to the Parties No. 2014, Haiti and Grenada should not request exports permits.

Other commodities in this fishery are the conch shells, the conch pearls and more recently the conch opercula (*e.g.*, Jamaica, Nicaragua and Colombia) (Figure 6). The queen conch pearls are by far the most valuable product in this fishery (with Japan as the major importer, followed by Switzerland and the US) and their trade is also the most difficult to control. Little is known about the recent operculum trade, but China is the major importer and it is believed to be used in traditional Chinese medicine. Both the conch shell and its operculum are utilized as souvenirs in the tourism industry in low numbers.

Conch fishing effort in the majority of the countries remains at an artisanal level. For instance, fishing in the eastern Caribbean consists of small canoes or dories of 7-10 m long, powered by outboard engines or sail and oars and carrying 1-4 divers. A regular day for conch fishing lasts approximately 8 hours, and mainly daily fishing trips.

In the French Antilles and other eastern island-states, the queen conch is captured also using nets (300-400 m long), with approximately 3 to 6 nets being pulled by the tide. In Martinique, there was a slight increase in net fishing between 1986 and 2006 (7 to 17 ships instead of 5) and a significant decrease in diving targeting queen conch (at the most,

7 ships instead of 23). In Guadeloupe, there are two types of nets to fish conch: fixed gillnets or trammel nets. Nets are expected to operate in shallow and deep waters.

Figure 6. Conch meat, conch shell and conch pearls main export products in the queen fishery.
Photos by: Oscar Ortegón and Martha Prada.

Artisanal captures conducted in distant fishing grounds are possible due to the use of mother ships vessels (10-15m long) that transport the small canoes and involve more fishers, approximately 7-10 divers, with trips lasting approximately 4 to 7 days.

In contrast, industrial fishing reaches even far offshore banks (40-160Nm from the landing sites) and takes place with the support of larger mother boats, made of steel-hull, up to 35m length and powered by inboard engines. These vessels can carry over 40 divers (some times more than 60 divers) plus the canoe drivers, for several weeks or months at a time. These vessels provide housing to the crew and divers and are used as a base for daily fishing trips where fishers use smaller dories with outboard engines or oars that carry 1-2 divers. In addition to free/scuba diving, industrial divers can use surface compressor (Hookah) diving techniques. Industrial fishing is taking place in Jamaica, Honduras, Nicaragua, and up to 2012 in Colombia, too. Normally, the meat is extracted from the conch underwater using a hammer and a knife, and later on, once on board the meat is pre-processed and stored.

In artisanal fishing, queen conch is landed alive or fresh, sometimes with the shell or at other times as unclean meat (with majority of organs attached). Artisanal fishing that uses mother boats usually lands refrigerated clean meat (trimmed meat with no organs). Industrial products are usually landed in bags of frozen clean meat. Processing grades adopted by countries in the region vary significantly; therefore, the real estimation of total queen conch production is difficult to calculate, because not every country has developed fishery specific conversion factors needed to obtain comparable production data. A kilogram of queen conch cleaned meat can be purchased at around $7-8 (US), several

thousand dollars can be paid for a good queen conch pearl, while for a nice conch shell is only worth a couple of dollars.

A majority of the countries have been progressively implementing their own sustainable fishery management programs, many times in response to coordinated regional efforts. Bermuda, the Netherlands Caribbean, Florida, Mexico and Venezuela have kept their conch fisheries closed. Colombia has reduced dramatically its fishing effort, eliminated industrial fishing, and conducted stock enhancement pilot projects on low conch density banks. Belize has established a series of no-take marine reserves and does not allow scuba diving (Gongora 2012). Cuba delimited only six fishing areas where the conch fishery can legally operate, and not all are open every year, or at the same time (Alvarez Lemus 2012). Increased patrolling within Tobago Marine Park, in the Grenadines, has resulted in an abundant queen conch population (SOFRECO 2013). As a result from the CITES moratorium, Honduras has implemented a survey monitoring program to determine their sustainable harvestable biomass and other important biological parameters.

To the contrary, some countries still need to improve their fisheries management to achieve sustainability and to promote fishery health and stability. Countries at major risk range from examples like Barbados, which are characterized by a limited resource due to a narrow shelf and a population dominated by juvenile conch, to countries like Nicaragua and Honduras, where divers are suffering frequent and severe bends resulting in several diver deaths annually and communities with high numbers of cripple fishers.

In general, countries regulate the minimum shell length, the minimum unclean or clean meat weight, imposes restrictions on fishing techniques, establish permanent or temporal close areas or seasons, and determine annual catch and export quotas (Tables 1 -2). The Organization of Eastern Caribbean States (OECS) has harmonized rules (i.e., minimum shell length of 178 mm and 225 g unclean meat weight) due to the OECS Common Fisheries Surveillances Zones Agreement in 1991, which is designed to improve regional cooperation between member states (Anon., 2007). However, in general, queen conch fisheries regulations are difficult to implement considering the following aspects:

1. While regulations exist to prohibit the taking, sale or possession of immature conchs, and a minimum conch shell length (17.8 to 22.0 cm) and a lip thickness (5 to 10mm) limits have been defined, the majority of the fisheries do not land the conch shells so that compliance cannot be assessed. Additionally, these morphometric measurements do not always indicate sexual maturity.
2. Similarly, regulations specifying minimum conch clean or unclean meat weight (225g to 100g), or prohibiting diced conch also are not good indicators of the individual maturity, or any other relevant biological criteria. In addition, processing is highly variable and no conversion factors are available for the various possibilities.
3. Variable close seasons exist, but several countries allow trade during this time, creating confusion and making surveillance and enforcement difficult.

4. Restrictions on diving techniques exist, particularly for scuba or hookah, but these are difficult to control due to low enforcement capabilities and remoteness of the fishing grounds.
5. The NDF documentation is a CITES requirement for all international shipments of conch, but it is a comprehensive process that requires expertise, applicable regulations and financial resources, not always available for all exporting countries.
6. In most countries, the fishery operates as an open access system, and number of fishers tends to increase with time, putting addition stress on the resource and making compliance more difficult to achieve.
7. Temporal closures and re-opening systems have proven effective in recovering queen conch populations, but production and marketing becomes highly variable, affecting the profitability of the fishery.
8. Prohibitions to the capture reproductive individuals (spawning or copulating) require voluntary fishermen compliance to be successful, and during the close season.
9. Protection of deep-water conch populations and recent protection of conchs within no-take areas appear to contribute in the increase of conch densities in fishing grounds, but these need full implementation of the conservation actions, which are not easily achievable.
10. Restrictions on the health and sanitary conditions of the queen conch products exist, but these demand access to ice, better handling/processing techniques and sanitary inspections of both harvest areas and finished product, again not always available to fishers or management agencies.
11. The number of countries demanding Vessel Monitoring Systems (VMS) is increasing, but unfortunately those data are not always available to fisheries management authorities, while VMS is an expensive system and creates technological challenges.

Table 1. Most recent descriptors of the queen conch fishery. Data taken from national reports available at the CRFM, FAO, OSPESCA and fisheries managers.

	Approx. No. fishers	No.small boats (dories)	No. industrial boats	only free diving	compressor	trip duration	Approx. annual production (mt)*	$US annual production (millions USD)	% export
USA.P Rico	128(2008)						88.9(2005)		
USA-USVI**							71(2005)		
Cuba				yes			295		
Martinique		14					3.4		
Guadeloupe		38-76		yes			30		
St. Kitts & Nevis	30	10				1	148 (2012) (unclean)		
Antigua & Barbuda	72	18				1	102 (2012) (unclean)		
St. Lucia	17-40	20				1	30-40) (2008) (unclean)	1.5(2008)	
Grenada						1	25 (2012)(unclean)		20-30
St. Vincent & the Grenadines	45	17				1	22.4(2012) (unclean)		10-20
Barbados	25						0,53		
Dominican Republic	1680-2018	247	40		yes		354.8 (2011)		
Haiti*	626	300-400		yes		2-3	200 (2012)		
Turks & Caicos	253	146				3-4	260.6 (2013)	3.8(2013)	46-51
Cayman Islands									
Bahamas	9300	4000					750 (2011)	3.5 (2011)	36
Jamaica*			6-7		yes		400-500 (2012)		90
Belize*	2759-2000	800		yes		6-12	389.3 (2011)	4.1 (2011)	85
Guatemala							42 (2007)		
Honduras	2000		13			22	210		90
Nicaragua	1650	70	22		yes	5-22	340-380 (2011)		90
Panamá						1			
Colombia	90	15		yes		6-10	16 (2011)		

*= If not stated, assumed to be clean conch meat.

Table 2. Variation of the queen conch close season in the Wider Caribbean.

Country	Months of fishing closed season											
	J	F	M	A	M	J	J	A	S	O	N	D
Antigua / Barbuda, St Kits & Nevis, Dominica, St. Lucia, Grenada, St Vincent / the Grenadines,							x	x				
Belize							x	x	x			
Cayman Islands					x	x	x	x	x	x		
Colombia						x	x	x	x	x		
Cuba					x	x	x	x	x			
Dominican Republic							x	x	x	x		
Guadeloupe	x	x	x	x	x	x	x	x	x			
St Barts / St Martin		x	x	x	x	x	x	x	x			
Jamaica	x							x	x	x	x	x
Martinique				x	x	x	x	x				
Nicaragua						x	x	x	x			
Haiti				x	x	x	x	x	x			
Turks and Caicos							x	x	x	x		
US Virgin Islands							x	x	x			
US Puerto Rico (State)								x	x	x		

*: Countries or territories not listed here prohibited the queen conch fishery or is a small fishery that operates without being. The Bahamas has close areas, but not a close season.

Table 3. Summary of updated estimation of conch densities in the Caribbean. Data comes from national reports, WECAP/FAO 2012 reports and other research.

Country	bank area	Adult density (ind/ha)	Juvenile density (ind/ha)	total dendity (ind/ha)	Primary Conch Fishing Banks
USA.P Rico		7.32 (2013)	6.73 (2013)	14.05 (2013)	Western insular platform, also south and east platform
USA-USVI		135 (2010)	90 (2010)	225(2010)	St.Croix
Cuba					
Aruba					EPICOL norte y sur, EPICAI, EPOISAN, EPISUR, EPINIO
Guadolupe				57-37 (2009)	Video transects, 8 sites in Grand Cul-de-Sac Marin, 4.7ha
Caribbean Netherlands				121(2012)	Survey only at St. Eustatius Marine Park
St. Kitts & Nevis					Northern & southern ends
Antigua & Barbuda	3400	17.2 (2001)	3.7-25.6 (2002)		
St. Lucia	522	242.9 (2008)			Northern and southern banks
Grenada	900				North, northeast, & southern banks
St. Vincent & the Grenadines	3000	50 (2013)	254.4 (2013)		Suervy only at Union Islands shelves in the Grenadines Banks
Angilla					
British VI					
Barbados	74,6	1.39(2010)	7.34(2010)	8.73(2010)	Southern and Western Island shelves
Dominican Republic	2013		53 (1997)		Pedernales, Beata Island, Jaragua National, Parque Este & Plata
Haiti		8(2009)	37.6(2008)	54(2009)	Canal du Sud and Anse a Pitres, shelvf around Gonave Island and Les Arcadins, Rochelois bank, Petite Goave and Grand Goave area, Les Cayemites
Turks & Caicos				50-100 (2008)	Over 860 stations simple each year, snorkel, shaalow sites
Cayman Islands				70-260 (2002)	
Bahamas	45000				Little Bahama , northern and central sections of the Great Bahama, Cay Sal Bank
Jamaica	8000			20-378 (2010)	Pedro Bank
Belize		123 (2013)			Northern banks
Costa Rica	45				Punta Malaquive
Honduras	10000	92-196 (2011)			Rosalinda, Middle, Oneida, Gorda
Nicaragua	4000	85-112 (2006)			Northern & South-eastern Miskitos, offshore banks
Panama	10000	1.43			Guna Yala banks
Colombia	3200	194.9 (2013)	157 (2013)	351.9(2013)	Serrana bank
Mexico	293				Alacranes

4.3. Challenges to the Queen Conch Fishery

Problems in the conch fishery are broad and cover many topics, including the complex biology of the species, the uncertainty of catch and effort data, the illegal trade, the weak surveillance and enforcement mechanisms, the unsustainable fishing practices and even the frequency of severe dive accidents, impacting the life in entire towns, among others. Problems in the fishery are dynamic, adding to the complexity fisheries managers need to confront and for which usually they do not have enough human, technical or financial resources. Table 4 presents a summarized description of those problems after carefully analyzing the queen conch fishery across the Greater Caribbean.

Addressing these problems would require an increase in compliance among fishers, processors and consumers, and more cooperation across all sectors. All stakeholders would need to understand the problems and work together to propose recommendations for their solution. Implementing a system where strategy development progressively changes from a top-down to a more bottom-up approach can contribute to make this change a reality.

Fisheries co-management is a strategy that can allow for greater participation in the management of fisheries, but its success requires proper legal framework, awareness of conservation and sustainable use constraints and willingness to participate. At present, fisher organizations are not empowered, such that fisheries co-management in the Caribbean remains at the pre-implementation phase (Lovell 2012), and continuous education programs to sensitize the public and create awareness about environmental issues and conservation of marine resources are in need (McConney et al. 2003).

Table 4. Summary of the problems in the queen conch fishery.

Topic	Description of the problem	Consequence
Biology of the species	-The species has multiple forms of shell growth (length, then lip-thickness). -Morphology is highly variable depending on local environmental conditions. -Size (and hence fecundity) is primarily fixed at time of maturation. -The species has highly variable growth and natural mortalities rates. -Successful conch recruitment is highly variable and may not happen every year.	-Dynamic population models difficult to apply.
Catch data	-Data is incomplete and not organized with statistical rigor. -In many cases historical data exist only in hard copies. -Data are available only for short periods of time. -Processors provide reports, but data are incomplete and difficult to verify. -Electronic reporting of purchased landings have not been evaluated yet, and do not account for total landings (Bahamas). -Fisheries managers do not have information to estimate unreported catches believed to account an important proportion of the total captures (Bahamas, Eastern Caribbean countries, Dominican Republic, and Colombia among others). -Local consumption of conch is often not monitored or included in the catch statistics. -There are differences in the processing of the conch meat (unclean to semi-clean or clean) with slight variations among countries. Processing degrees are usually not incorporated in the estimation of the conch production. - Catch data from certain sites/times need to incorporate an extrapolation factor to calculate total production, and this factor changes through time.	-Total conch production is estimated with high uncertainty. -Surplus production models difficult to apply. -Difficult to determine sustainable harvestable biomass.
Conversion factors	-Conversion factors for conch meat are available only in few countries (i.e., Antigua and Barbuda, Bahamas, Belize, Dominican Republic, Jamaica, Honduras, Martinique, Mexico and Nicaragua). -Inexistence of simple definition of conversion factors to accommodate various processing across the region.	-Difficulties in comparing time series of catch data or data from multiple sites.
Fishing effort	-Difficult to account for potential increase in number of fishers in response to human population increases. -Continuous and unquantified improvements/changes in diving and other techniques. -Continues changes in the number and size of the mother vessels. -Frequent changes or expansion of conch fishing grounds. -High spatial variability in the allocation of fishing effort in small areas (conch aggregations).	-Difficult to standardize effort/catchability over time. -Difficult to standardize effort/catchability across methods. -Inclusion of spatial parameters needed, but often not available.

Conch surveys	-Widely different survey methods are used relative to number of sites, area surveyed per site, information collected (spatial/habitat distribution, number, size/age class, reproductive activity) -Widely different areas are surveyed (e.g., whole shelf, just known fishing grounds, deep areas not always included). -Surveys demand access to habitat maps, nautical charts, trained divers, safe diving protocols and availability of proper working platforms, not always available. -Surveys require good statistical design and clear data analysis, and access to appropriate level of statistical expertise. -Conch appear to refuge in deep areas (30-50m);sampling at these depths may require special underwater video systems, or use of re-breathers and mixed-gas diving, both based on specialized training and dependent on securing enough funding. -Greater success of conch surveys is achieved with the participation of scientists and fishers, but no always the case.	-Poor statistical survey design may result in biased or variable estimates of population size/density and age structure, and not track changes in these over time -Poor logistical survey design may waste time and effort, resulting in variable estimates and lack of needed information -Standardized surveys within country may track density, but estimates not comparable across countries -Standardized surveys within country may track density, but estimates not comparable to suggested target densities, such as those based on maintaining active reproduction. -Capabilities and experience may not exist within agencies/country. - Recurrent funds need to be identified if surveys are integrated as a monitoring program -The deeper the area to be surveyed, the greater the costs.
CITES permits	-Queen conch exports need to be well documented, with certification of origin and legality, issued if conchs were taken without negatively affecting the natural conch populations, difficult to determine with certainty. -Not every country in the region has developed their Non-Detriment Finding. -Not all export products are being regulated (conch pearls, shells, trimmings, operculums) to determine their legality. -Exports lacking proper CITES documentation are occurring, particularly among neighboring countries. -CITES permits are issued without proper scientific backup from the scientific authority.	-In the absence of studies needed to verify NDFs, and proper regulations of all conch commodities, CITES authorities (Scientific and administrative) find it difficult to certify the not detrimental nature of the export.

Unsustainable fishing practices/Habitat concerns	-Where conch populations have declined, a rebuilding plan is require, but this is usually not considered. -Habitat degradation via siltation, sedimentations or pollution may negatively affect conch populations, and needed habitat restoration efforts are not always in place. -In many places, conch nursery areas have not been identified. In many places, conch spawning populations have not been identified -There are areas where sub-adults are being targeted. -Deeper stocks are assumed to be unexploited, but diving is going deeper through time due to lack of alternatives or introduction of new technology. -Many MPAs are too small to protect the various conch life stages through ontogeny, or not well enforced, may not be effective in preserving sufficient spawning stock biomass.	-Sufficient spawning stock, or spawners at low density may lead to recruitment failure. -Inshore nursery areas may be at risk to habitat degradation and loss of nursery function. Management has not incorporated precautionary principles and population and fishery are at risk. Management does not have an ecosystem basis and population and fishery are at risk. -Sites with reduced conch population may not recover with reduction of fishing pressure alone.

Surveillance and Enforcement	-It is not clear whether existing regulations are sufficient or effective due to poor monitoring and little enforcement mechanisms in place. -Patrolling of fishing grounds often conducted by maritime/military personnel who need specific training to recognize legal vs illegal fishing activity, but training lacking. -Patrolling needs to verify compliance with diving regulations, which is difficult. -As the fishing grounds move towards more distant places, logistics and funding for patrolling become an important limiting factor. -Military/enforcement personnel are frequently rotated, thus training needs to be incorporated during their basic courses, a decision that requires the participation of high-level officials. -Fisheries managers process fishing violations through civil or penal judicial systems, so they need to be aware of a) the importance of collecting good evidence, b) how to keep a good chain of custody, and c) how to interact within the national and international legal systems. However, they do not have all the needed strengths. -National regulations often have penalties either too low or too high, or inappropriate sanctions negatively affect fishermen compliance, thus undermining the effectiveness of the legislation. -Where fishing violations involve people from different nationalities, procedures and involvement of foreign affairs ministries, health departments and migratory authorities are necessary, but their role is not always considered. -Evaluation of regulatory effectiveness frequently requires collection of data in the field and not just at landing sites, but this kind of program is rare in the region. -Establishment of observer programs allowing the collection of good data is difficult because of need for trained personnel, and sufficient funds. -VMS information is in place in some countries, however real-time data not always available for fisheries managers and other government entities participating in surveillance and enforcement. -Effective patrolling often depends on coordination between enforcement personnel and fisheries managers to reach potential lawbreakers at the right site or time. -Enforcement success requires regional cooperation, which can be affected by complex geo-political issues. -Drug or immigration control and not fishing are the highest priorities during enforcement patrols. -With such a broad involvement of government offices attending illegal fishing issues, there is need for a protocol, but usually is unavailable. -Administrative/ judicial process can take longer than expected. -Benefits of available technology is not always maximized due to technological, administrative or political issues.	-Enforcement can become inefficient or ineffective. -Enforcement costs are increased. -Repeat violators continue to fish illegally. -Inability to prosecute/fine offenders, particularly of outside fishers, affects credibility and reduces incentive for voluntary compliance. Partnerships between enforcers, managers and fishers needed for co-management cannot be established.

Illegal, Unreported, Unregulated (IUU) fishing	-Regulations control minimum shell sizes and meat weights, but frequently conch shells are not land, and alternative metrics based on landed meat (e.g., weights) are not established or defined. -Many aspects of the fishery remain unregulated (e.g., meat trimmings, pearl trade, proper conversion factors, diving safety). -Lack of inspections to verify conch production statistics (Guatemala, Dominican Republic, Panama, Costa Rica, etc.) or indicate where national reports perhaps include significant illegal trade. -Existence of complex network of smugglers that trade out at sea and involve operations in several countries.	-The proportion of the illegal fishing or trade remains undefined in the majority of countries. -Complex networks of conspirators can put enforcers and honest fishers at risk. - Regional collaboration is needed among stakeholders if Illegal fishing is to be carefully addressed
Human safety	-Repetitive scuba diving has resulted in severe health problems mainly in Honduras and Nicaragua, but also in other countries. -Conch divers have a 5 times higher re-incidence rate than other divers. -Lack of training, proper equipment, good maintenance, and work under strenuous physiological conditions are key factors contributing with a vast of diving diseases. -Development and enforcement of governmental controls and preventive protocols are needed to prevent diving accidents and permanent injury. -Diver training programs are needed to prevent diving accidents and permanent injury. -In industrial fisheries (i.e., with mother boat) parties responsible for enforcing protocols need to be identified and held accountable. -Access to hyperbaric treatments have been proven to significantly reduce the extend of diving related injuries, but these often are not readily available. -Conch meat can deteriorate during transit, processing or at point of sale due to the lack of ice or live wells. -Divers reluctant to follow proper diving procedures due to cultural factors and illiteracy in some countries. -Influence of drugs abuse, alcoholism and prostitution in some countries. - Divers are not included in the social security system.	-Diving accidents and permanent injury lead to human suffering in families and communities. -Diving accidents and permanent injury lead to loss of efficiency and income. -Diving accidents and permanent injury increase burden on health care facilities and programs. -Programs providing physical and financial access to hyperbaric treatments are needed. -Unsanitary practices can lead to contamination of the conch meat with *E coli* bacteria. -Unsanitary practices and contamination can lead to loss of customers and market share. -Contamination increases burden on health care facilities and programs.
Participation in the decision making process	-Low participation of the fishers in the fisheries management decisions. -Fishermen are not empowered to participate more actively in fisheries management. -Fisheries management is not allocated the required resources to respond to complex administration. -Despite the fact that most fishermen understand the problems, they require constant education and outreach programs.	-Fisheries co-management in the Caribbean remains at the pre-implementation phase. -Incentives for voluntary compliance are lost and enforcement costs go up.

5. Goals and Objetives

The queen conch management in the WECAFC region should achieve the following objectives and goals:

- Promotion of regional conservation measures aimed to maintain or increase the density of natural queen conch populations, across the shallow and deep-water habitats the species utilizes through ontogeny.
- Adoption of regional sustainable harvest strategies needed for long-term a healthy queen conch fishery. This strategy would include maintenance of high population biomass, controlled queen conch harvest, and high economic benefits for present and future generations in accordance with the FAO Code of Conduct for Responsible Fisheries, and CITES recommendations.
- Incorporation of CITES legal acquisition and no detriment findings and, if appropriate, export quotas, into management plans of all countries exporting queen conch.
- Endorsement and implementation of management regulations to increase controls for the reduction of IUU in the queen conch fishery.
- Introduction of precautionary principles in the queen conch regional fisheries management in order to maintain healthy queen conch populations and to rebuild depleted stocks.
- Incorporation of polices in the queen conch fishery that lead to improvements in fishermen health and the sanitary conditions of queen conch products for consumers.
- Increase coordination and collaboration allowing for better education and outreach, monitoring and research and co-management, and consequently strengthen, optimize and harmonize governance arrangements for implementing ecosystem approach for queen conch fishery in compliance with the Strategy Action Program of the Caribbean Large Marine Ecosystem agreements.

6. Management Measures

The following management measurements are proposed to address the challenges in the fishery and to incorporate recommendations made by the Queen Conch Expert Workshop (QCEW), held in Miami, USA, 22-24 May 2012, validated by the Working Group during the meeting in Panama City on 23-25 October 2012, and further supported by CITES 16.141 decision. It is recognized that sub-regional organizations (CFMC, OSPESCA, CRFM) have made some progress towards more sustainable fisheries administration in the Wider Caribbean.

<u>Short-term (1-3 years)</u>

a) Work towards the establishment of a harmonized closed season in the queen conch, considering the species peak reproduction during warmer months, the

timing of close seasons for other stocks, the conditions at sea, and the economic importance of resource for artisanal fishers. A closed season might be first imposed on industrial fishers, with much higher extraction capabilities relative to artisanal fishers fishing from small boats. During a closed season, fishing and exports should be banned. The measure requires a clear definition about who would be considered an artisanal conch fisher, and the criteria to differentiate artisanal fishing from industrial fishing. Aldana et al. (2014) recommended a regional queen conch close season from June 1 to 30 September.

b) Define harmonized and simplified categories of queen conch meat processing, for which countries would develop their own conversion factors. Catch data used in statistics and quota definitions should incorporate those conversion factors.
c) Work collaboratively in determining the level of local consumption of queen conch products and the importance of family income resulting from this fishery in the region, including food security.
d) Each exporting country will define their own Non-Detriment Finding for the queen conch fishery, with national and sub-regional mechanisms in place for their implementation. Use legal acquisition and no detriment findings and export quotas as integral parts of management plans.
e) To introduce precautionary criteria into the conch meat export trade, a minimum conch weight should be established, and no conch trimmings should be allowed.
f) Promote the use of free diving in the queen conch fishery and prohibit the use of hookah. Adopt stricter regulations when scuba diving is exercised to reduce risks associated with decompression sickness.
g) Develop sub-regional mechanisms to control queen conch IUU fishing including, but not limited to organized patrolling, and establishing legal consumption and restaurant certification programs.
h) Develop a continuous education and outreach programs for various stakeholders in order to improve understanding of the importance of the species ecological role in the ecosystem looking for greater compliance of fisheries management strategies.
i) Produce and legally adopt national fishery management plans documenting inter alia the harvest strategy, decision-making process and roles and responsibilities of all stakeholders.

<u>Mid-term (3 to 6 years)</u>

a) Adopt sub-regional mechanisms and protocols to conduct conch surveys in order to make scientific recommendations on harvestable biomass that have immersed precautionary principles, overcoming the need for credible and long-term information requirements in dynamics or surplus production assessments. Existing protocols conducted in Belize, Jamaica, Colombia, Honduras and Nicaragua can be taken as examples.

b) Adoption of population reference points may need to be included in the fisheries management regulations, including topics regarding the percent of fishable biomass, and the minimum conch density, among others.
c) Agree on sub-regional research and monitoring plans addressing fisheries dependent and independents aspects such as recruitment patterns and its relation to seasonal fishing strategies, climate change effects or genetic connectivity, effects of catastrophic events, among others.
d) Extend the use of VMS systems for the conch fleet for all countries in the region, for boats larger than 10m-long to enhance compliance relative to trade and closed areas, to increase fishermen safety at sea and to determine spatial patterns of the use of queen conch fishing grounds.
e) Define enforcement protocols (sub-regional) including chain of custody, interaction among various government organizations, and the role of international agencies.
f) Develop and progressively implement a certification program to promote the legal conch consumption in the Wider Caribbean.

Long-term (6 to 10 years)

a) Develop and implement a digital catch and effort data entry and analysis system, with the participation of national management units and regional advisory groups.
b) Progressive inclusion of co-management strategies by building capacity of fishermen organizations, establishing administrative fisheries centers, and adjusting legal frameworks.
c) Develop and implement a limited entry system that can prevent increases in fishing capacity until the potential yield can be determined.
d) Utilization of no-take MPAs as a precautionary measure to improve queen conch conservation, stock rebuilding and management.
e) Develop collaborative arrangements needed to generate habitat maps at the scale needed for better fisheries management.

7. Implementation arrangements

7.1. Establishment of Regional Harvest Strategy

The harvest strategy consists of four steps: improving data collection, performing credible data analysis, defining control rules, and applying scientific recommendation using the control rules. Every phase would comprise the following strategies:

Data collection: In the short-term, the improvement of data collection can be done by:

- Conducting more and better-structured conch surveys and improving mechanisms for reporting and monitoring catch and effort data.

- Compiling, organizing and digitizing historical conch fishery data from analogue format, applying conversion factors and determining the degree of conch products used for local consumption.
- Work in cleaning and improvement of existing digital databases at national or sub-regional level.

In the long-term, data collection can be improved by:

- Establishing a mandatory report of fisheries-dependent information, not only for industrial or processors, but also for all fishermen and processors.
- Establishing a program to electronically report fishery-dependent data in real-time by structuring an online platform for sharing and storing queen conch information (Figure 7).
- Compiling data in national databases, incorporating conversion factors and mechanisms for quality control, for analysis at the national level.
- Storing and sharing national databases in a WECAF server, for analysis on a regional level, and link with CITES Secretariat.

This digital system is based on an ID verification, the security system that grants (or denies) access to the online platform. It will check if the access request comes from a registered user. In addition, depending on the user type and permissions, the ID verification system will allow viewing, retrieving and modifying specific set of files stored in the platform. Fishers can access the online platform by sending their information through a special app that works from a mobile phone or a tablet. It is possible they can also send a text message with the requested information. Case studies in the Bahamas or Belize, where digital systems are being utilized, can be analyzed for further development.

To incentivize the fishers to report their daily operations, applications from gaming concepts can be applied, so they can receive in return for their reports scores, points, levels, etc. that can be associated with their permits and allow for social networking among them. Gamification provides two main advantages. First, it allow for rewarding behaviors and activities, while allowing tracing of users since game elements act like sensors in a system; second, it provides the sense of progression and enables competition.

Data analysis: Once having proofed databases on catch and effort, data become available and analysis can be improved by:

- Establishing a National Analysis Group comprised of, for example, scientists and managers from the CITES scientific and administrative national authorities control rules, a representative of the fishing community. They will then better estimate conch population abundance indices such as: corrected CPUE, or representative density of the conch natural population.
- Analyzing scenarios resulting from the application of fishery restrictions/ precautionary principles contemplated by this National Analysis Group would assist the Group prior to making final recommendations.

- Allowing for participation of outside government scientists to join the analysis working group, which would increase credibility in its results.

Control Rules: Depending on the country, several control rules will be utilized towards improving sustainability in this fishery. Adoption of the QCEW reference points and control rules are advised.

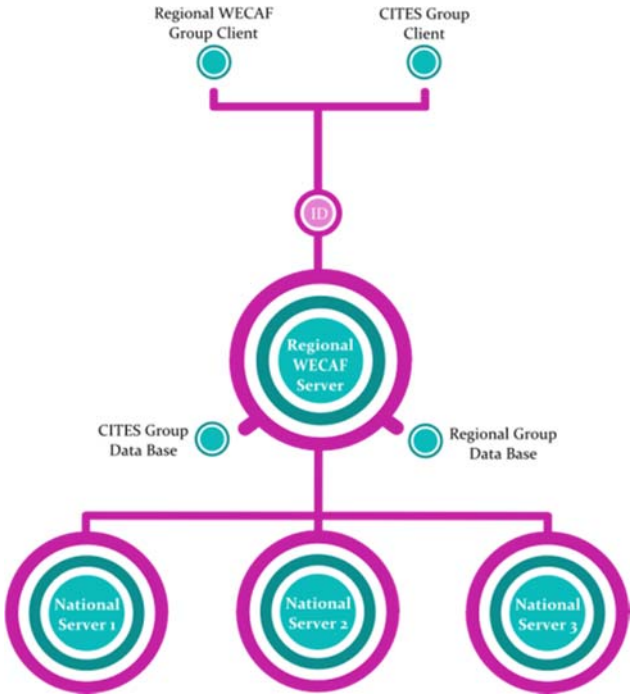


Figure 7. Simplified diagram of the electronic centralized queen conch catch and effort data collection and storage system.

Application of management controls: Success in applying management controls increases stakeholders compliance. The following strategies would contribute to this purpose:

- Utilize existing sub-regional organizations to improve coordination among government offices and resource users.
- Increase communication mechanisms among stakeholders.
- Strengthen education and outreach at all times and all levels.

7.2. Implementation of Additional Regional Measures

- Organize personal or online regional encounters to analyze the pros and cons of having a harmonize closed season in the conch fishery.

- Conduct dedicated training and equipment safety inspections in those places using scuba diving. Promote the use of free diving and the prohibition of the use of hookah in the queen conch fishery.
- Develop a regional educational and outreach program can address the following stakeholders:
  - Higher government officials/decision-makers – focus should be on understanding of the importance of data collection, scientific analysis, research, training, and capacity building to manage a shared living marine resource.
  - Fisheries officers, data collectors, data-clerks, market enumerators – focus should be on understanding the purpose and use of the data they collect, and why it needs to be accurate.
  - Fishermen and processors - focus on awareness of the species's ecology, ecosystem role and the impact of fishing and market demand on the sustainability of the stock.
  - General public – focus should be on general issues and need of environmental protection and conservation of marine resources. School children and high-school students would be priority targets. As a result of the education programs, progressive implementation of the co-management system may become a reality.
- Develop pilot projects focused on more responsible consumption of queen conch products, with the participation of health authorities, hotels associations, NGOs and fisheries managers, among others.

7.3. Implementation of sub-regional measures

Considering the complex political Caribbean geo-political arrangements, sub-regional organization (OCS, CRFM, OSPESCA, The CFMC, Oldepesca) can play an important role towards coordination and implementation of the queen conch fisheries management plan. Strategies considered at this level include:

- Organization of sub-regional workshops to discuss and adopt common sampling protocols in conch surveys, including proper statistical design, and developing special and free software routines for data analysis
- Implement pilot projects to conduct trans-boundary conch surveys following adopted sampling design and data analysis protocols.
- Lead initiatives to develop and adopt sub-regional research and monitoring plans, enhancing the way scientific advice guides management decision making. The research plan may be re-evaluated every five years to re-orient priorities.
- Provide mechanisms for organizing sub-regional working/advisory groups, sharing technical, human and financial resources to conduct data analysis and gathering other needed information, including habitat mapping, population reference points, or identified priorities for countries in the sub-region.

- Strengthen existing sub-regional enforcement mechanisms to counteract problems in the queen conch fishery, including enforcement protocols and chain of custody.
- Promote the establishment of deep-water trans-boundary MPAs network to protect queen conch reproductive stocks.

8. Monitoring and review

Type	Indicators to measure	Frequency	Requirements
Catch and effort	-Total catch, standardized fishing effort, CPUE, rate of national consumption, total exports.	Close to real-time as possible	-Fishermen and processor reports. -Inspector reports from landing sites, processing facilities, restaurants. -Design and operation of centralized database, with time series data. -Application of conversion factors.
Trade and other socio-economic parameters	-Detailed national and international trade of the queen conch products. -Fishermen/family socioeconomic indicators.	Close to real-time as possible	-CITES documentation, fisheries and health inspections, NDF available, socio-economic interviews.
Conch surveys	-Conch densities, % adults & juveniles, % fishable biomass, size/age distribution, spatial distribution and habitat use, existence of spawning stocks and nursery areas. Recruitment indices and patterns. During surveys additional aspects such as spatial and temporal patterns of recruitment or genetic studies can be integrated.	Every three to four years	-Work platform, trained personnel, good diving equipment and protocols, good sampling design, data analysis unit and regional advisory group.
Spatial fishing patterns	-Patterns of spatial distribution of fishing patterns. Generate detailed maps of conch fishing grounds, related to benthic maps and nautical charts & MPA boundaries.	Periodic revision needed	-Access to VMS data, good nautical charts and benthic maps, fishermen interviews.
Listing of violators	-Generate an online database to report fishing violators internationally.	-Permanent	-Work collaboratively among stakeholders.
Human health	-Statistics of diving disease, number of diving associated fatalities	-Permanent	-Work with doctors and hospitals, especially at sites operating recompression chambers.

9. References

Acosta, CA. 2001. Assessment of the functional effects of a harvest refuge on spiny lobster and queen conch populations at Glover's Reef Belize. Proc. Gulf Caribb. Fish. Inst. 52: 212-221.

Acosta, CA. 2006. Impending trade suspensions of Caribbean queen conch under CITES: a case study on fisheries impacts and potential for stock recovery. Fisheries. 31(12): 601-606.

Alcolado, PM. 1976. Crecimiento, variciones morfológicas de la Concha y algunos datos biológicos del cobo *Strombus gigas* L. (Mollusca, Mesogastropoda). Acad. Cien. Cuba Ser. Oceanol. No 34: 36pp.

Aldana Aranda, D, L Frenkiel, E Baqueiro Cardenas, A Zetina Zarate, G Garcia Moliner, A Rodriguez, J Mateo Perez, A Tagliafico, E Castro, T Camarena and G Arenciba. 2007. Geographic distribution of Apicomplexa infecting *Strombus gigas*. Proc. Gulf Caribb. Fish. Inst. 59: 321-325

Aldana-Aranda, D., E.R. Baqueiro-Cárdenas, I. Martínez-Morales, R.I. Ochoa, and T. Brulé. 2003. Reproductive patterns of *Strombus gigas* from Alacranes Reef versus Chinchorro Bank of México. Proc. Gulf Caribb. Fish. Inst. 54: 202-225.

Aldana D. H.A. Oxenford, C. Bissada, M. Enriquez, T. Brulé, G.A. Delgado, I. Martínez, and L. Frenkielet. 2014. Reproductive patterns of queen conch, *Strombus gigas* (mollusca gastropoda) across the wider Caribbean. Bull. Mar. Sci. 90: 813-831.

Alvarez Lemus J.A. 2012. Informe de Cuba al grupo de trabajo CFMC/OSPESCA/ COPACO/CRFM sobre el estado de la pesca del caracol reina (cobo). In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 99-102p.

Appeldoorn, RS. 1988. Age determination, growth, mortality and age of first reproduction in adult queen conch, *Strombus gigas* L., off Puerto Rico. Fish Research. 6: 363-378.

Appeldoorn, RS. 1994. Spatial variability in the morphology of queen conch and its implications for management regulations. Pages 145-157 in: RS Appeldoorn and B Rodriguez (eds). Queen conch biology, fisheries, and mariculture. Fundación Cientifica Los Roques, Caracas, Venezuela

Appeldoorn, R.S., 1997. The biology of queen conch and its impact on stock assessment, IN: Posada, JM, G Garcia-Moliner and IN Oliveras. 1997. Proceedings of the International

Queen Conch Conference. Caribbean Fisheries Management Council. San Juan, Puerto Rico. 160.

Appeldoorn, RS. 1997. Deep Water Spatial Variability in the morphology of Queen Conch and its implication for management regulations. In CFRAMP (Ed.): Lobster and Conch subproject specification and training workshop, 9 to 12 October 1995, Kingston, Jamaica, CARICOM Fishery Research Document No. 19.

Appeldoorn RS, L Arango, F Cabeza, ER Castro, R Glazer, T Marshak and G Peñaloza. 2003. Queen conch distribution and population assessment of the northern banks of the San Andres Archipelago, Colombia. Final report Northern expedition, CORALINA-The Ocean conservancy. San Andrés. 27 p.p.

Appeldoorn, RS. 1994b. Spatial variability in the morphology of queen conch and its implications for management regulations. Pages 145-157 in: RS Appeldoorn and B Rodriguez (eds). Queen conch biology, fisheries, and mariculture. Fundación Cientifica Los Roques, Caracas, Venezuela.

Appeldoorn, RS, JA Rivera and A. Maldonado. 2011. A re-examination of the peak spawning season for queen conch in Puerto Rico. Final Report to the Carribbean Fishery Management Council, San Juan, Puerto Rico

Appeldoorn RS and N. Baker. 2013. A literature review of the queen conch, *Strombus gigas*. Department of Marine Sciences, University of Puerto Rico. Unpublished. 80p.

Appeldoorn, R.S., E. Castro Gonzalez, R. Glazer, M. Prada. 2011. Applying EBM to queen conch fisheries in the Caribbean. Pp. 177-186, *In:* Lucia Fanning; Robin Mahon; Patrick McConney (Eds.). Towards Marine Ecosystem-based Management in the Wider Caribbean. Amsterdam University Press. Amsterdam.

Barnutty Navarro R.R., y R.S. Castellón. 2012. Informe nacional de Nicaragua. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 124-129p.
Bjorn K. 1997. Caribbean coral reef, seagrass and mangrove sites. UNESCO, France.

Borrell, B. 2013. Ocean conservation: a big fight over little fish. Nature, 493: 597–598.

Brito, M.N., D. Aldana-Aranda, L.E. Cruz, and M.A. Estrada B. 2006. Organogénesis larvaria de *Strombus gigas* (Mesopoda:Strombidae) en el arrecife Alacranes durante el periodo máximo de su época reproductiva. Universidad y Ciencia 22:75-82.

Cala de la Hera, YR, A de Jesús-Navarrete, JJ Oliva-Rivera and FA Ocaña-Borrego. 2012. Auto-ecology of the Queen Conch (*Strombus gigas* L. 1758) at Cabo Cruz, Eastern Cuba: Management and Sustainable Use Implications. GCFI. 64: 342-348

Campton, DE, CJ Berg Jr, LM Roblson, RA Glazer. 1992. Genetic patchiness among populations of the queen conch *Strombus gigas* in the Florida Keys and Bimini. Fishery Bulletin. 90: 250-259.

Castro, E.R, M.C., Prada, J.P. Caldas, and V. Puentes. 2012. Manejo Pesquero y Conservación del Caracol Pala (*Strombus gigas*) en Colombia. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/ WECAFC/CRFM Working Group on Queen Conch. 92-98p.

Cimo, L., D.W. Meadows, N. Daves, and G. Garcia-Moliner. 2012. The Status of Queen Conch Fisheries and National Summary Report for the United States of America. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 145-153p.

CITES. 2003. Review of Significant trade in specimens of Appendix II species (Resolution Conf.12.8 and decision 12.75). 19th meeting of the Animals Committee. Geneve. 71p.

Clerveaux, W and D Vaughan. 2003. An investigation of the effects of increasing fishing efficiency on the productivity of queen conch (*Strombus gigas*) and Caribbean spiny lobster (Panilus argus) fisheries within the Turks and Caicos Islands. GCFI. 54: 285-296.

CRFM. 2006. Report of Second Annual Scientific Meeting – Port of Spain, Trinidad and Tobago, 13-22 March 2006. CRFM Fishery Report - 2006, Volume 1. 188 p.

CRFM. 2012. Report of Eighth Annual Scientific Meeting – Kingstown, St. Vincent and the Grenadines, 20 - 30 June 2012. CRFM Fishery Report - 2012. Volume 1. 150p.

Chalifour, J. 2009. Development of an Evaluation Method of the Queen conch (*Strombus gigas*) Resources in Guadeloupe and Application to Eight Marine Sites in the Archipelago. GCFI. 61: 509-513.

Davis M. 1998. The effects of natural foods, temperature and salinity on the length of larval life for the tropical gastropod *Strombus gigas*. PhD dissertation, Florida Institute of Technology, Melbourne, FL.Davis et al. 1990.

Davis, M, CA Bolton and AW Stoner. 1993. A comparison of larval development, growth, and shell morphology in three Caribbean *Strombus* species. The Veliger. 36(3): 236-244

Delgado, GA, RA Glazer, D Hawtof, D Aldana Aranda, LA Rodriguez-Gil and A De Jesús-Navarrete. 2008. Do queen conch (*Strombus gigas*) larvae recruiting to the Florida Keys originate from Upstream sources? Evidence from Plankton and drifter studies. Pages 29-41 in: R Grober-Dunsmore and BD Keller, eds. Caribbean connectivity: Implications for marine protected area management. Proceedings of a Special Symposium, 9-11 November 2006, 59th Annual Meeting of the Gulf and Caribbean Fisheries Institute, Belize City, Belize. Marine Sanctuaries Conservation Series ONMS-08-07. U.S. Department of Commerce. NOAA. Office of National Marine Sanctuaries. Silver Springs, MD.

de Jesús-Navarrete, A. 1997. Densidad, estructura de tallas y actividad reproductiva del caracol rosado Eu*Strombus gigas* (Mesogastropoda: Strombidae) en Banco Chinchorro, México. Revista de Biología Tropical 61:1657-1669. ,

de Jesus-Navarrete, A and D Aldana-Aranda. 2000. Distribution and abundance of *Strombus gigas* veligers at six fishing sites of Banco Chinchorro, Quintana Roo, Mexico. Journal of Shellfish Research. 19(2): 891-895.

Department of Environment and Maritime Affairs. 2013. Turks and Caicos Islands National Report on the Queen Conch Fishery 2012/2013.

Department of environment Cayman Islands. Conch surveys. http://www.doe.ky/marine/conch/ conch-survey/

Egan, BD. 1985. Aspects of the reproductive biology of *Strombus gigas*. MSc Thesis, University of British Columbia, Vancouver, Canada.

Garcia-Sais JR, J Sabater-Clavell, R Esteves and M Carlo. 2012. Fishery independent survey of commercially exploited fish and shellfish populations from mesophotic reefs within the Puertorican EEZ. Submitted to CFMC, San Juan PR. 91p.

Glazer, R. A., and J. A. Kidney. 2004. Habitat associations of adult queen conch in an unfished Florida Keys back-reef: applications to essential fish habitat.Bull. Mar. Sci. 75:205–224Glazer and Delgado 2012.

Gittens L.G. and M.T. Braynen. 2012. Bahamas national report. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 70-73p.

Gongora M. 2012. Belize National Conch Report 2012. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 80-84p.
Gordon, S. 2010. USVI queen conch stock assessment 2008-2010. Final Report to SEAMAP. 29p.

FAO/WECAFC/COPACO/CFMC. 2012. Report of the first meeting of the CFMC/OSPESCA/ WECAFC/CRFM Working Group on Queen Conch. FAO Fisheries and Aquaculture Report No. 1029. Ciudad de Panamá, Panamá, 23-25 de octubre de 2012. 171p.

Frenkiel L, P Laurent, A Zetina Zarate, and Aldana Aranda D. 2009. Reproduction Cycle of the *Strombus gigas*, L. 1758 in Guadeloupe, FWI. Proceedings of Gulf and Caribbean Fisheries Institute. Vol 61: 518-520.

Heyliger S. J. 212. National Report on the Queen Conch (*Strombus gigas*) for St. Kitts and Nevis. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 130-132p.

Horsford I.S. 2012. The Status of the Queen Conch Fishery of Antigua and Barbuda. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 133-138p.

Haftof, D.B., K.J. McCarthy and R.A. Glazer. 1998. Distribution and abundance of queen conch, *Strombus gigas*, larvae in the Florida Current: Implications for recruitment to the Florida keys. Proc. Gulf Caribb. Fish. Inst. 50: 94-103.

Hubert-Medar, Patricia and S., Parker Willimas. 2012. . National summary report for the status of queen conch fishery in St. Lucia, In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 133-84p.

INPESCA. 2011. Plan de reconversión laboral técnica y ocupacional para los pescadores que utilizan la técnica del buceo en la pesca de langosta. Instituto Nicaragüense de la Pesca y la Acuicultura. 127p.

Isaacs, K. 2012. National Report – St. Vincent and the Grenadines. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 133-138p.

King-Joseph A., Lendor-Gabriel G.Serieux N., and St. Omer A. 2008. Conch resource assessment study. Technical document Ministry of Economic Affairs, Economic Planning, Investment & National Development, Department of Fisheries. St. Lucia. 124p.

Lovell, T. 2012. Towards a management plan for Antigua and Barbuda's queen conch fishery: a co-management approach. United Nations University, Fisheries Training Program. Iceland. Final project. http://www.unuftp.is/static/fellows/document/tricia12prf.pdf.

Mahon, R., L. Fanning, R. and P. McConney. 2012. Governance assessment methodology for CLME pilot projects and case studies. Centre for Resource Management and Environmental Studies, University of the West Indies, Cave Hill Campus, Barbados, CERMES Technical Report No 53 (English): 20pMartin-Mora, E., F.C. James and A.W.

Márquez-Pretel, E., E. O. Davila-Vila, J. Gallo-Nieto. 1994. Dinámica poblacional y pesquera del caracol *Strombus gigas* Linnaeus, 1758 en las Islas de Providencia y Santa Catalina. Bol. Cient. INPA 2: 110-123.

Márquez, E., R.M., Landínez-García, S.P. Ospina-Guerrero, J.A. Segura, M.C. Prada, E.R. Castro, J.L., Correa, and C. Borda. 1012. Genetic analysis of queen conch *Strombus gigas* from the Southwest Caribbean. Proceedings of Gulf and Caribbean Fisheries Institute. Vol 65: 410-416.

McCarthy KJ, CT Bartels, MC Darcy, GA Delgado and RA Glazer. 2002. Preliminary observation of reproductive failure in nearshore queen conch, *Strombus gigas* in the Florida Keys Proc. Gulf Caribb. Fish. Inst. 53: 674-680.

McConney, P., Pomeroy, R. and Mahon, R. 2003. Guidelines for Coastal Resource Co-Management in the Caribbean: Communicating the Concepts and Conditions that Favor Success. Caribbean Coastal Co-management Guidelines Project. Caribbean Conservation Association.

Mateo J. 2012. Informe Nacional Sobre la Pesquería del Lambí (*Strombus gigas*) en la República Dominicana. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the

first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 103-110p.

Mattos-Caraballo, D. and J. Agar. 2011. Census of Active Commercial Fishermen in Puerto Rico: 2008. Marine Fisheries Review 73(1):13-27.

Medley, P. 2008. Monitoring and managing queen conch fisheries: a manual. FAO Fisheries Technical Paper. No. 514. Rome, FAO. 2008. 78p.

Mianmanus RT. 1988. Induction of settlement and metamorphosis in larvae of *Aplysia brasiliana* and *Strombus gigas* (Mollusca:Gastropoda) – A Dissertation. University of Miami. Coral Gables, Florida. 171p.

MRAG 2013. Support to improve and harmonize the scientific approaches required to inform sustainable management of queen conch (*Strombus gigas*) by CARIFORUM States ACP Fish II Porject CAR/3.2/B.15, final report. 287p.

Mitton, JB, CJ Berg Jr and KS Orr. 1989. Population structure, larval dispersal, and gene flow in the queen conch, *Strombus gigas*, of the Caribbean. Biological Bulletin. 177: 356-362.

Morris, R. 2012. Jamaica national Queen Conch (*Strombus gigas*) report. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 120-123p.

Murray. A., S., Smikle, R., Morris, K., Cooke-Panton, J., Squire, and F., Hansel. 2012. Assessment of the 2012 catch and effort data for Pedro Bank. Ministry of Agriculture and Fisheries,Fisheries Division. 13p.

Oxenford, H.A., C. Gooding, J. Walcott, T. Staskiewicz and H. Valles. 2010. Assessment of the queen conch, *Strombus gigas*, in Barbados. Report prepared for the Natural Heritage Department and the Environmental Unit, Ministry of Environment, Water Resources and Drainage, Government of Barbados, 49 pp.

Oxenford, H.A. 2012. Status of the queen conch fishery in Barbados. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 74-79p.

Pérez-Pérez, M. and D. Aldana-Aranda. 2003. Actividad reproductiva de *Strombus gigas* (Mesogasteropoda: Strombidae) en diferentes hábitats del Arrecife Alacranes, Yucatan. . Rev. Biol. Trop. 51(4): 119-121.

Prada, M, E Castro, E Taylor, V Puentes, R Appeldoorn and N Daves. 2008. Non-detrimental findings for the Queen Conch (*Strombus gigas*) in Colombia NDF Workshop Case Studies WG 9 – Aquatic Invertebrates Case Study 3. 51p.

Randall, JE. 1964. Contribution to the biology of the queen conch *Strombus gigas*. Bulletin of Marine Science. 14: 246-295

Richardson, P.L. 2005. Caribbean current and eddies as observed by surface drifters. Deep Sea Research Part II: Topical Studies in Oceanography 52(3-4):429-463.

Luis A. Rodriguez Gil. 1995. Biochemical composition of larval diets and larvae, temperature, and induction of metamorphosis related to the early life history of the milk conch, *Stombus costatus* Gmelin. Ph.D. Dissertation, UPR-Mayaguez

Sheppard, C.R.C. (Ed.) 2000. Seas at the millennium: an environmental evaluation: 1. Regional chapters: Europe, The Americas and West Africa. Pergamon: Amsterdam. ISBN 0-08-043207-7. XXI, 934 pp.

Sen S, and JR Nielsen 1996. Fisheries co-management: a comparative analysis, Marine Policy, 20 (5), 405-418.

SOFRECO 2013. Training in underwater visual survey methods for evaluating the status of *Strombus gigas*, queen conch stocks. ACP Fish II – Strengthening fisheries management in ACP states 9 ACP RPF 128 Accounting No. RPR/006/07 – EDF IX, final report. St. Vincent and the Grenadines. 359p.

Suazo, J.J. 2012. Informe nacional de Honduras. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 116-119p.

Stoner, AW and VJ Sandt. 1992. Population structure, seasonal movements and feeding of queen conch, *Strombus gigas*, in deep water habitats of the Bahamas. Bulletin of Marine Science. 51: 287-300.

Stoner, A., VJ Sandt and IF Boidron-Metairon. 1992. Seasonality in reproductive activity and larval abundance of queen conch. Fishery Bulletin 90: 161-170.

Stoner, AW and KC Schwarte. 1994. Queen conch, *Strombus gigas*, reproductive stocks in the central Bahamas: distribution and probable sources. Fishery Bulletin. 92: 171-179.

Stoner. 1995. Developmental plasticity in the shell of the queen conch *Strombus gigas*. Ecology. 76:981-994.

Stoner, AW, RA Glazer and PJ Barile. 1996. Larval supply to queen conch nurseries: relationships with recruitment process and population size in Florida and the Bahamas. Journal of Shellfish Research. 15(2): 407-420.

Stoner, AW, N Mehta and TN Lee. 1997. Recruitment of Strombus veligers to the Florida Keys reef tract: relation to hydrographic events. Journal of Shellfish Research. 16: 1-6.

Stoner, AW and M Ray-Culp. 2000. Evidence for Allee effects in an overharvested marine gastropod: density dependent mating and egg production. Marine Ecology Progress Series. 202: 297-302.

Stoner, A. and M Davis.2010. Queen Conch Stock Assessment Historical Fishing Grounds Andros Island, Bahamas. Retrieved Oct 1, 2012 from http://www.community conch.org/ wpcontent/uploads/2010/10/AndrosReport.pdf.

Stoner, A, M Davis and C Booker. 2009. Queen Conch Stock Assessment Proposed MPA and Fishing Grounds Berry Islands. Bahamas, Community Conch, Bahamas.

Stoner, A, M Davis and C Booker. 2011. Surveys of queen conch populations and reproductive biology at Lee Stocking Island and the Exuma Cays Land and Sea Park, The Bahamas. Community Conch, Bahamas.

Stoner, AW, KW Mueller, NJ Brown-Petersen, MH Davis and CJ Booker. 2012b. Maturation and age in queen conch *Strombus gigas*: Urgent need for changes in harvest criteria. Fisheries Research. 131-133: 76-84.

Tello-Cetina, JA, LA Rodriguez-Gil, F Rodriguez-Romero. 2005. Population genetics of the pink snail *Strombus gigas* in the Yucatan Peninsula: Implications for its management and fisheries. Ciencas Marinas. 31(2): 379-386.

Theile, S. 2001. Queen conch fisheries and their management in the Caribbean. Traffic Europe. 96p.

Torres-Rosado, ZA. 1987. Distribution of two mesogastropods, the queen conch, *Strombus gigas* Linnaeus, and the milk conch, Strombus costatus Gmelin, in La Parguera, Lajas, Puerto Rico. MS Thesis, UPR, Mayagüez Campus. 37 pp.

Van Rijn J. 2013. Population assessments of the queen conch *Strombus gigas* in the St. Eustatius Marine Park. Imares Wageningen and University of Applies ScienceVan Hall Larestein. Unpublished Technical Document. 37p.

Van Baren P.K. 2012. National report on the status of the Queen Conch fisheries of the Caribbean Netherlands. In: FAO Fisheries and Aquaculture Report No. 1029. Report of the first meeting of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch. 85-91p.

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

Wood E. 2010. Status and management of queen conch in Haiti. Marine Conservation Society. Ross-on-Wye, UK.65p.