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P.O. Box 1390, Skulagata 4
120 Reykjavik, Iceland

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TOWARDS A MANAGEMENT PLAN FOR ANTIGUA AND BARBUDA'S QUEEN CONCH FISHERY: A CO-MANAGEMENT APPROACH

Tricia Lovell
Antigua Fisheries Division
Point Wharf Fisheries Complex
Lower North St., St. John's
tricial@lycos.com

Supervisor:

Jónas Hlynur Hallgrímsson
University of Iceland
Reykjavik, Iceland
Jhh4@hi.is

ABSTRACT

Queen conch is a large, sedentary, long-lived species of mollusc that is vulnerable to overexploitation throughout much of its lifetime. Antigua and Barbuda's queen conch fishery is relatively small, however it holds the potential to contribute to the nation's economic development once proper measures are put in place to optimize economic benefit to communities while maintaining stock sustainability. Given the small, homogenous nature of the fishery, a co-management approach is recommended as the most appropriate management regime to achieve this. This document presents a proposal for a co-management plan for Antigua and Barbuda's queen conch fishery. The primary goal of the plan is to ensure the sustainable harvest of queen conch resources in Antigua and Barbuda's waters through the adoption of a participatory approach to management while maximising economic and social benefits to fishing communities engaged therein. A simple bioeconomic model is used to gauge the current state of the fishery and to determine effort levels that will help to optimise profit.

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ABBREVIATIONS

ABDFCG	Antigua Barbuda Defence Force Coast Guard
CARICOM	Caribbean Community
CBMR	Cades Bay Marine Reserve
CFMC	Caribbean Fisheries Management Council
CFO	Chief Fisheries Officer
CFRAMP	CARICOM Fisheries Resource Assessment and Management Programme
CITES	Convention on International Trade in Endangered Species
CMT	Customary Marine Tenure
CPI	Consumer Price Index
CPUE	Catch Per Unit Effort
CRFM	Caribbean Regional Fisheries Mechanism
ECCB	Eastern Caribbean Central Bank
EEC	European Economic Community
EU	European Union
FAC	Fisheries Advisory Committee
FAO	Food and Agriculture Organisation
JICA	Japanese International Cooperation Agency
LFMA	Local Fisheries Management Authority
LW	Live Weight
MCS	Monitoring Control and Surveillance
MEY	Maximum Economic Yield
MPA	Marine Protected Area
MSY	Maximum Sustainable Yield
MT	Metric Tonnes
MW	Meat Weight
NEMMA	Northeast Marine Management Area
NOAA	National Oceanic and Atmospheric Administration.
NTAC	National Total Allowable Catch
OSPESCA	Organización del Sector Pesquero y Acuícola de Centroamerica
SPAW Protocol	Protocol Concerning Specially Protected Areas and Wildlife
TAC	Total Allowable Catch
TURF	Territorial Use Rights in Fishing
UNEP	United Nations Environment Programme
US	United States
USVI	United States Virgin Islands
WECAFC	Western Central Atlantic Fisheries Commission
XCD	East Caribbean Dollars

1 INTRODUCTION

Queen conch (*Strombus gigas*) is a marine gastropod of the order megagastropoda and one of the largest strombid snails in the Caribbean. The species is known to reach recorded shell lengths up to 300 mm and is easily distinguished from other similar species by its characteristic pink flared aperture (Randall 1964). The species is subject to relatively heavy fishing pressure throughout its distribution range and has suffered localised stock collapses, most famously in Florida where the fishery collapsed since the mid-1970s. Despite numerous efforts at re-stocking, Florida's queen conch fishery has yet to recover, prompting US authorities to restrict commercial fishing in that state.

According to Thiele (2005) several characteristics of queen conch make them particularly vulnerable to overfishing:

- They are thought to be long lived reaching sexual maturity relatively late (3 – 5 years after hatching)
- They mate in large and highly visible spawning aggregations
- They are known to occur in shallow waters making them easy to capture
- Once numbers reach below a certain stock density reproductive activity declines

Queen conch is a high valued species across its range, second only to spiny lobster in many territories. Because of this and the relatively high fishing pressure, concerns have been raised about its conservation status prompting a number of regional and international interventions. Many of the regional efforts have focused on cooperation in improving knowledge of the species' biology and conservation status, with a few focusing on harmonised management. On the other hand, international efforts have focused on monitoring trade impacts, since international trade in queen conch has been found to be a major driver of fisheries across its range.

In Antigua and Barbuda the queen conch fishery though relatively small is thought to have the potential to be an extremely valuable resource. Management of the species has so far been primarily through biological control measures aimed at protecting juvenile life stages. The purpose of this research paper is to present a proposal for the management and conservation of queen conch resources in Antigua and Barbuda, utilising a co-management approach. The objectives of the paper will be to:

- Review the Antigua and Barbuda queen conch fishery;
- Conduct an assessment of optimal management strategies for the fishery; and
- Develop a framework co-management plan for the resource

2 SPECIES PROFILE

2.1 Habitat and Distribution

Queen conch has a relatively wide distribution range as it is found throughout the Wider Caribbean in the territorial waters of approximately 36 countries and territories in the region. Its recorded range is from the Gulf of Mexico in the northern Caribbean to Venezuela's Orinoco River in the South (Figure 1).

Figure 1. Distribution range of queen conch in the Wider Caribbean (National Marine Fisheries Service NOAA 2012).

The species is known to inhabit different depth contours throughout its life ranging from a few centimetres to depths in excess of 100 metres (Thiele 2001). However, stock densities generally decline below 30 metres owing to light limitations and the lowered availability of its main food source (Thiele 2001). Queen conchs are commonly found on sandy bottom substrate stable enough to support the growth of marine plants (Brownell and Stevely 1981). However, specimens have also been found in hard bottom habitats such as coral rubble, gravel, smooth hard coral and beach rock bottoms (Brownell and Stevely 1981).

The species is known to exhibit two types of migration patterns, ontogenetic migration with adults typically being found further offshore than juveniles and reproductive/spawning migration. In addition to seasonal migration, Stoner *et al.* (1988) observed the mass migration of juveniles in conch populations in the Bahamas over 14 weeks. The authors surmised that this mass migration represented an ontogenetic shift in habitat from soft sandy bottom substrate in which juveniles are known to burrow during their first year of life to a more vegetated substrate for grazing.

2.2 Biology of *Strombus gigas*

Queen conchs are herbivores with a diet composed of both micro and macro algae, first as benthic juveniles and later as adults (Stoner 1997). Their morphology is largely controlled by the external environmental characteristics of their habitat. Thus factors such as depth, substrate type, quality and quantity of available food and stock density are known to affect growth rates and species morphology (CFMC and CFRAMP 1999). Growth rate has also been found to be positively correlated to the final shell length with animals that exhibit slow growth rate being comparatively smaller than those that grow at a faster rate (Alcolado 1976). While maximum shell length is achieved at sexual maturity, older conch is generally smaller than younger adults. Over time the shells of adult queen conch may become inundated with boring animals, which slowly erode its outer surface (Randall 1964).

2.3 Life History

While queen conch spawning has been reported year round it is highest between April and September. However, this may vary depending on external environmental factors such as temperature, turbulence and perhaps density. Queen conchs mate in large, highly visible aggregations, numbering in the thousands (Ehrhardt and Valle-Esquivel 2008). Spawning will only begin once the female has selected the proper substrate; clean coral sand with low organic matter (D'Asaro 1965). The adherence of clean sand to the egg mass provides camouflage for developing embryos (Brownell and Stevely 1981). Fertilisation is internal and copulation lasts for several hours. Spawning takes between 24 – 36 hours (Stoner and Ray-Culp 2000). Eggs are produced as a long continuous tube sticking together in a mass (Brownell and Stevely 1981). Females lay between 4 – 9 egg masses over the course of the spawning season each holding several hundred thousand eggs (Stoner and Ray-Culp 2000).

Approximately five days after the egg mass is produced hatching begins and the veliger larvae emerge beginning their pelagic life stage (D'Asaro 1965). A study conducted by Stoner and Davis (1997b) showed that larvae of queen conch were found from the ocean surface up to depths of 100 metres. However, they were most prevalent in the upper mixed layer of the ocean thermocline between 25 – 30 m (Stoner and Davis 1997b). Stoner and Davis (1997a) also found that larval abundance was influenced by the density of adjacent spawners. Free floating larvae feed on phytoplankton (Brownell and Stevely 1981) and have a dispersal range up to a few hundred kilometres.

Once larvae settle, 17 – 22 days post emergence, the dispersal range is largely reduced and metamorphosis begins. At this point the velar lobes disappear, eyes begin to migrate outwards and the proboscis (or grazing organ) is completed (Brownell 1977). Complete metamorphosis typically occurs between 28-33 days after hatching, depending on the quality and availability of food (Brownell 1977). Post metamorphosis juvenile conch begins to form a tiny white shell, secreted by the orange yellow mantle, which surrounds the conch’s soft body (Davis 2005). Shell length increases until the time of sexual maturity at which point the shell develops a flared lip, which starts to thicken. Maturity is typically reached three and a half years after larval settlement (Stoner *et al.* 2012). The queen conch is gonochoristic (unisexual) and exhibit sexual dimorphism, with females of the species being on average slightly larger than males (Randall 1964).

Because the shell starts to erode over time and erosion rates may vary depending on habitat, it is difficult to estimate conch age based solely on the morphology of the shell. Similarly, meat weight (MW) varies with age and may begin to lose mass in very old conch (Medley 2008). The queen conch is thought to have a maximum longevity of between 20-30 years. Once they mature, adult conch has a relatively low natural mortality as compared to juveniles of the species (Medley 2008).

Several studies have concluded that there is an apparent, density dependence for successful reproductive activity in queen conch populations. Stoner *et al.* (2012) note that for animals that actively copulate or require close proximity for the fertilisation of eggs to occur population densities are particularly important. Queen conchs are quite vulnerable to depensatory effects. Depensatory effects or depensation occurs when populations exhibit negative growth rates of population below critical population density (Stoner *et al.* 2012).

3 STATUS OF THE QUEEN CONCH FISHERY IN ANTIGUA AND BARBUDA

The Fisheries Division collects a range of data that helps to gain insight into the status of the queen conch resources in Antigua and Barbuda. The sampling programme attempts to target at least 5% of fishing effort, measured as number of fishing days. The system is a multi-tiered data collection process that includes sampling catches at landing sites or at market for the purpose of determining annual landings, effort, catch per unit effort (CPUE) levels and biological profile of landed species. The data programme also collects limited economic data on fisheries operations such as fuel used and tanks dived.

Table 1 presents an overview of the queen conch data collection system and fisheries research programme including information on parameters measured, units used, and sampling procedures. As is apparent from the table, the data collection programme is approximately 21 years old, with landings data available from 1991. However, for data prior to 1995 there is no information available on methodologies used in collection or analysis of data, therefore there is uncertainty regarding the quality of this data.

Table 1. Data collected by the Fisheries Division's data collection programme (Adapted from Horsford 2006).

	Description of Data	**Unit of Measurement**	**Years Available**	**Sampling Procedure**
Data Collection Programme	Total Production (landings)	Grams of marketable meat (raised to metric tonnes for total production)	1991 to 2010	– Sampling of active conch vessels; at least 5% of est. total trips
	Fishing effort (CPUE estimates)	No. of vessels No of SCUBA divers No. of tanks used No. of dives No. of fishing days	1995 – 2010	– Sampling of active conch vessels; at least 5% of est. total trips – Vessel frame survey
	Trip profile	Qualitative; areas fished, fuel used, start and end time.	1995-2010	– Sampling of active conch vessels, at least 5% of est. total trips
	Mean depths dived	Feet	2006-2010	– Sampling of active conch vessels; at least 5% of est. total trips
	Mean MW	Grams of marketable meat	1995 – 2010	– Sampling for biological data; at least 5% of estimated trips
	Size frequency	– Grams of meat – mm shell length and lip thickness	1995-2010	– Sampling for biological data; at least 5% of estimated trips
	Trade – Mass – Value	– Metric tonnes – East Caribbean Dollars (XCD)	Fairly good data prior to 1997	– Export warrants and health certificates signed by CFO
Research	Stock densities	No. of individuals/ha	1999 for limited area of shelf	– Belt transect – 34 randomly selected sites from 4 zones
	Morphometric Analyses	– Weight in grams – Shell length – Lip thickness – Sex & maturity	1999 and 2011	– Commercial landings and research trips

As illustrated in the table the Fisheries Division routinely collects three different types of data on queen conch; catch and effort data (landings, CPUE estimates), biological data (MW, size frequency), and trade data. In addition the Division has also engaged in a number of research activities to determine stock structure and abundance.

The information gathered through routine data collection and research activities is analysed using various analytical methods. These are presented in Table 2 along with the major results and conclusions from the research undertaken.

Table 2. Data analysis methods utilised for stock assessment (Adapted from Horsford 2006).

	Model/Method Used	Data Used	Summary of results and conclusions
Research Projects	1. Cadima Model 2. Schaefer Model 3. Fox Model 4. Next Fully Recruited Year Class	Conch abundance survey data – belt transects	Overall densities of adult conch low in study area – possibly overfished
Research Projects	Morphometric analysis of two stocks using simple linear regression, t-test for difference of means, chi-square goodness of fit	Research data: Total weight Shell weight MW Lip thickness	Sexual dimorphism Significant difference in sizes of the two conch populations (southwest and northwest)
Research Projects	Morphometric analyses of fishing areas around Antigua and Barbuda	Research data: Total weight Shell weight MW Lip thickness	Sexual dimorphism among adults Difference conch age between west and east coasts of Antigua Difference in conch size between west and south coasts of Barbuda
Data Programme	Trend analysis/ANOVA Mean CPUE, mean depth dived, mean marketable MW	Catch and effort and biological data	No significant negative trend regarding CPUE, depth dived or MW

All the data that is prepared for the Division is also provided to the Food and Agriculture Organisation (FAO) database and the offices of the Caribbean Regional Fisheries Mechanism (CRFM), a regional fisheries management organisation under the umbrella of the Caribbean Community (CARICOM).

3.1 Structure of Antigua and Barbuda's Queen Conch Stock

Relatively little is known about absolute densities and abundance for queen conch stocks in Antigua and Barbuda's waters. Despite this, it has long been suggested that traditional conch areas in Antigua and Barbuda are likely overfished. This assertion appears to be backed by the findings from the 1999 conch abundance survey conducted within traditional fishing grounds on Antigua's southwest coast. That study sampled 12.84 hectares of the 23 543 hectare traditional fishing grounds on Antigua's southwest coast. Overall conch densities recorded for the survey site were found to be well below what has been proposed as a viable population density for sustainable stocks (Tewfik *et al.* 2001).

Tewfik *et al.* (2001) reported that the survey sites showed overall conch densities of 17.2 conch per hectare with juvenile classes (juveniles and sub-adults) being the most abundant.

Adult densities for the survey area averaged 3.7 adults per hectare. Distribution across depth profiles and habitat types were consistent with what is known about the behaviour of the species. Adult conchs were found to be in higher densities in deeper areas of the survey site (>18 metres) while the highest densities of all classes was found in algal plains (25.4 conchs per hectare) and coral rubble (26.1 conchs per hectare). Densities in coral reefs and sand plains were extremely low as would be expected.

Tewfik *et al.* (2001) proposed that conch abundance surveys provide the most reliable assessment of stock abundance for queen conch given the animal's sedentary nature. CPUE estimates, they noted, are a poor index for stock abundance given poor estimates for fishing effort, changing catchability and the non-random distribution of fishing effort over space and time.

3.2 Profile of the Fishing Fleet

The Fisheries Division conducts an annual vessel frame survey in order to determine the active fleet in each year. Antigua and Barbuda's queen conch fleet is relatively small when compared to other fisheries. Most of the conch operators are based on the south coast of Antigua in the villages of Old Road and Urlings.

Prior to 2008 the number of active conch diving vessels stood relatively steady, with between 7-10 vessels operating. However in 2008, as the demand for spiny lobster reduced, a number of full-time Antiguan based spiny lobster vessels moved into the conch fishery essentially doubling the number of active vessels in 2009 and 2010 (Figure 2). These new entrants into the conch fishery operate on a part-time basis, dividing their effort between diving for conch and targeting spiny lobster. The fishery in Barbuda on the other hand is primarily subsistent to part time commercial since most of the vessels based on that island target spiny lobster for export (Horsford *et al.* 2011). Only one vessel targets conch in Barbuda on a full-time basis.

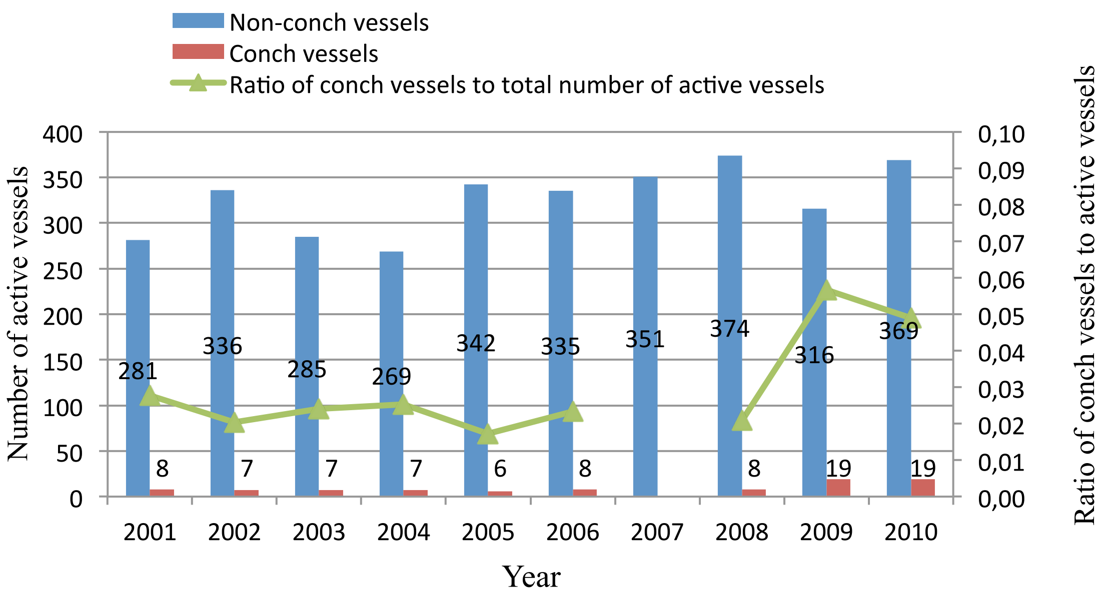

Figure 2. Active conch fishing vessels in Antigua and Barbuda 2001 – 2010 as compared to the rest of the fishing fleet (Fisheries Division 2012).

Conch fishing vessels range in size from small open pirogues of 4 metres to larger fiberglass launches up to 14 metres and equipped with hydraulic haulers and GPS equipment (Horsford *et al.* 2011). Typical investment in the queen conch fishery range from approximately 60,000 East Caribbean Dollars (XCD), in the case of smaller open pirogues, to 210,000 XCD for larger vessels (Horsford 2012). Up to 72 individuals are employed in the fishery representing approximately 7.6% of all active fishers. Forty of these individuals are employed as SCUBA divers on vessels. The current conch fleet stands at 17 vessels, 10 of which operate on a full time basis (Table 3).

Table 3. Profile of the commercial conch fishing fleet in Antigua and Barbuda for 2012.

Size Class	Type	Number of Units	Avg. Engine HP	Avg. No. of Divers	Avg. No. Of Crew
4.6-6.1 m.	Open	4	65.8	2	2
6.4-9.1 m.	Open Pirogue	7	131.4	3	5
6.1-9.1 m	Launch	2	305	1.5	2.5
>9.1 m	Launch	4	266.3	6	7

Queen conch is harvested by hand using SCUBA gear with commercial vessels carrying between 2-3 divers on smaller vessels and as many as 5-7 divers on larger vessels. Each diver uses an average of two, 80 cubic feet tank per trip. This is possible primarily because the 3 400 km^2 of Antigua and Barbuda's shelf has a mean depth of about 27 metres. The use of SCUBA in the conch fishery carries it with it inherent health and safety risks for participants. Diving in relatively deep areas of the Antigua Barbuda shelf queen puts conch fishers at risk to contract decompression sickness (colloquially termed "the bends"). Decompression sickness occurs when nitrogen builds up in the venous circulation and tissue caused by a decrease in ambient pressure as a diver ascends to the surface (Merlin *et al.* 2009). Deep and repetitive diving and rapid ascent after diving put divers at greater risk to contract decompression illness (Merlin *et al.* 2009), which may lead to paralysis or death in severe cases. Between 2006 and 2010 the mean depths dived by commercial conch divers has declined from 28.3 metres to 21.9 metres.

Traditional commercial conch dive sites are located in nearshore waters mainly off the southwest coast of Antigua. However, in recent years vessels have begun to explore newer areas further offshore. Most of these newer areas are located to the northeast of Antigua and in the area between Antigua and Barbuda referred to as "Centre". In addition vessels from Antigua have also started to explore fishing grounds west and southwest of Barbuda. Conch divers typically rotate fishing areas throughout the year, spending half the year on the south coast of Antigua and the other half in north. Both of these practices combined may have contributed to the rise in CPUE (conch per day trip) that has been observed in the fishery. Traditional conch fishing areas off Barbuda are in the shallow waters west of the island, relatively close to the Codrington Lagoon (Figure 3).

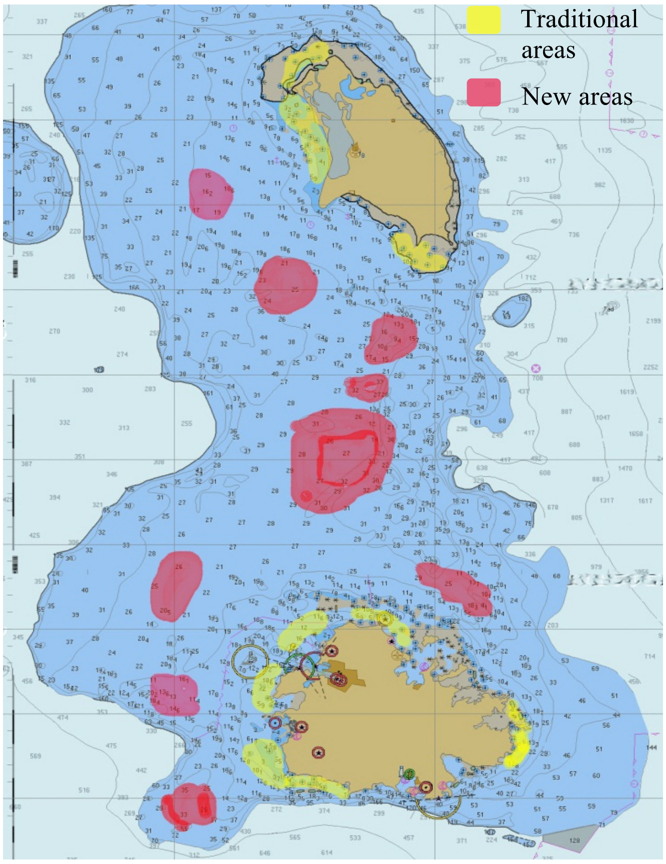

Figure 3. Conch fishing areas off Antigua and Barbuda.

The majority of Antigua and Barbuda's queen conch fishery is concerned with the harvesting of the animal for its meat. There is some limited trade in conch shells to tourism markets and in pearls to local jewellers; however both are largely secondary industries. Only the meat of the conch is landed therefore, a conversion factor must be applied to landed MW in order to get an estimate of total live weight (LW) of the animal. The Fisheries Division applies a conversion factor of 7.5 as provided by the FAO to convert landed "dirty meat" (conch meat with the viscera removed) to LW. This figure may need to be reviewed based on the findings of two conch morphometric analyses conducted by the Fisheries Division in 2011 and 2012. The studies sampled conch from 19 sites around Antigua and Barbuda, and the following parameters measured; sex, maturation stage (juvenile, sub-adult, adult and old adult), shell length, lip thickness (where relevant), LW (of the animal intact), shell weight, and MW at three levels of processing (intact, with digestive gland removed and cleaned). In both studies statistically significant levels of sexual dimorphism was observed in adult conch with females being 4% larger than males. Further, conversion factors observed were found to vary across maturation stage and in the case of dirty meat was found to be less than 7.5. Horsford *et al.* (2011) recommended that conversion factors ranging from 6.09 to 7.12 be applied to catches depending on the maturity of landed meat.

3.3 Trends in Landings and Fishing Effort

In 2010 landed MW of queen conch was estimated to be just over 100 metric tonnes representing 4.4% of total fisheries landings. Considering the value of species landed, queen conch landings for that year accounts for approximately 6% of the overall value of the fisheries sector based on present prices; 2.1 million XCD of 34 million XCD for all species (Figure 4).

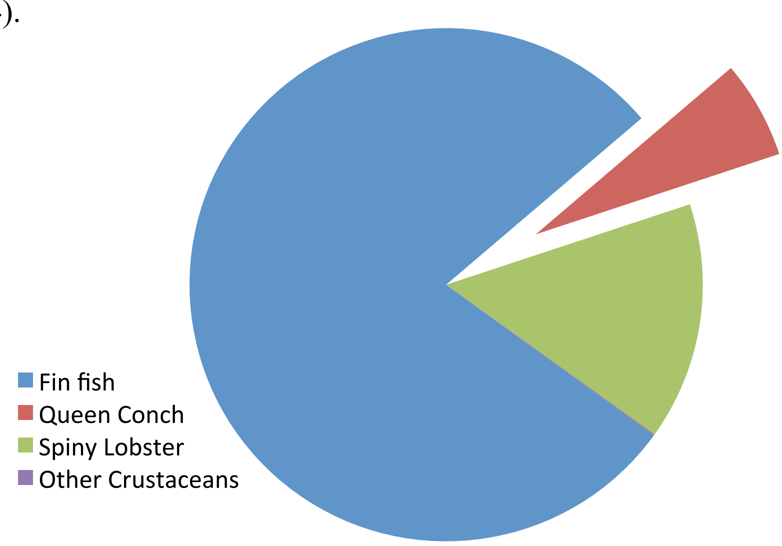

Figure 4. Comparative value of fisheries products in 2010 (Fisheries Division 2012).

While landings appear relatively stable between 1995 and 2001, there appears to be a slow increase in subsequent years up until 2008, where landings suddenly spike (Figure 5). Queen conch landings range from a low of 263 metric tonnes in 1997 to a high of more than 1, 300 metric tonnes in 2008. After peaking in 2008, conch landings declined in the subsequent two years. In 2010 queen conch landings stood at 764 metric tonnes (LW), an estimated value of 2.13 million XCD. While the steady increase prior to 2008 is likely a direct result of fishers moving to other areas, the observed spike and rapid reduction between 2008 and 2009 may directly be attributed to the increase and subsequent decrease in fishing effort as vessels moved into and out of the fishery.

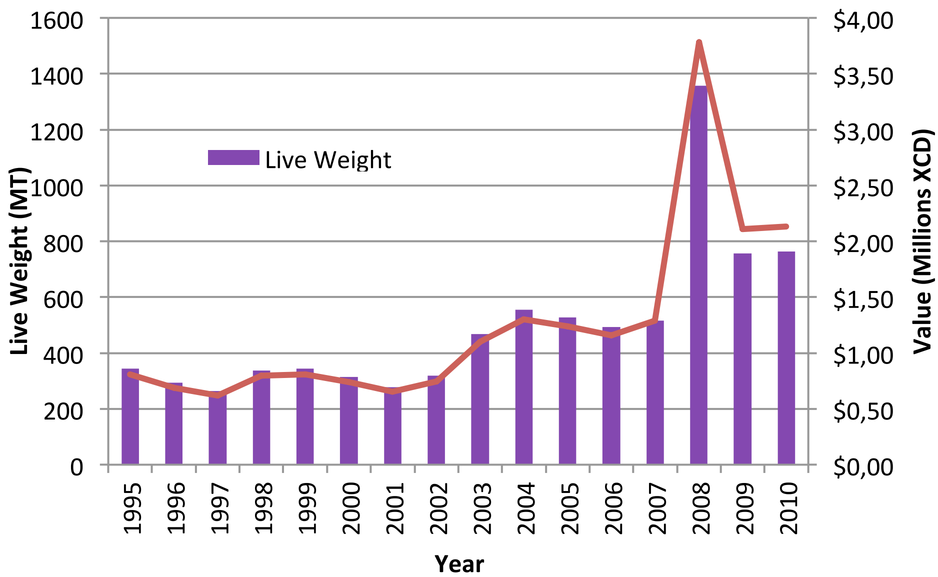

Figure 5. LW and value of queen conch landed in Antigua and Barbuda for the period 1995 – 2010 (Fisheries Division 2012).

Figure 6 depicts the relative change in capture production of queen conch and spiny lobster from 2005 – 2010 when compared to the previous 10-year average of each. This analysis appears to show a marked decline in lobster production in 2008 as conch landings increase, and continuing in 2009 and 2010.

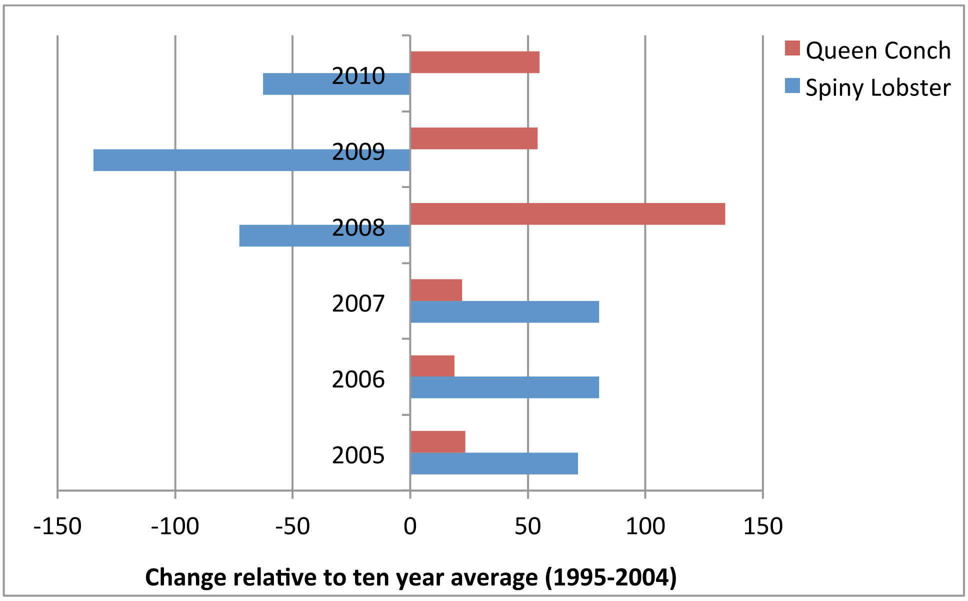

Figure 6. Comparative change in production of conch and lobster for the period 2005 – 2010 as compared to the previous 10-year average (Fisheries Division 2012).

Trends in overall landings are consistent with what is observed when reviewing Catch Per Unit Effort (CPUE) estimates. This metric has been estimated for queen conch landings using two different parameters (catch rates measured in terms of day trip and in terms of tanks dived). Since 1995 data have shown a general increase in CPUE in terms of day trip (Figure 7). A data gap exists for 2007 due to limited data collection in that year.

Figure 7. Catch Per Unit Effort of queen conch meat (kg/day trip) over the period 1995-2010 (Fisheries Division 2012).

Day trip catch rates are directly correlated to the trends observed in total landings over the period. This is not surprising since estimates of day trip are used to raise this CPUE estimate in order to determine total landings. As in the case of landings, CPUE increases in the fishery from 2001 onwards are likely a direct result of fishers exploring new areas. It may also be

the result of changes in fleet capacity as more fibreglass launches enter the fleet, which have the capacity to go further and stay longer at sea.
Prior to 2008 fishing effort (fishing days) for the conch fishery was relatively stable ranging between 720 fishing days to 953 fishing days. However, as a result of increases in the number of fishing vessels in 2008, the conch fishery recorded almost a doubling of effort when compared to 2006 estimates, moving from an estimated 720 fishing days to in excess of 1,500 fishing days in 2008 (Figure 8).

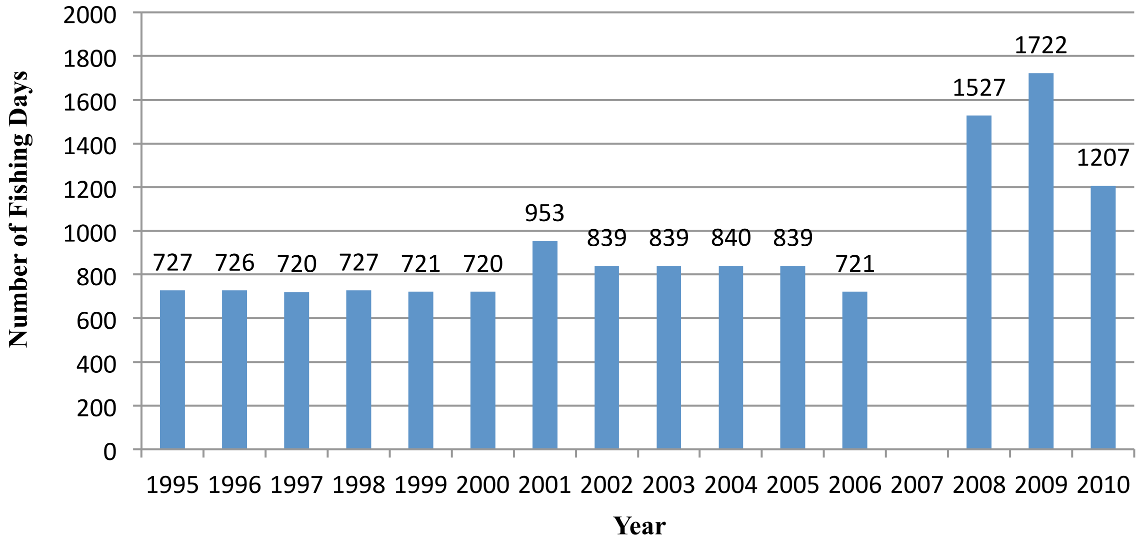

Figure 8. Estimated number of fishing days in the queen conch fishery for the period 1995 - 2010.

In regards to CPUE as a measure of tanks dived, a general increase is also observed, but this does not directly correlate to trends observed in day trip CPUE measures. For instance, between 2003 and 2006 while catch per day trip increases catch per tanks dived is seen to fall (Figure 9).

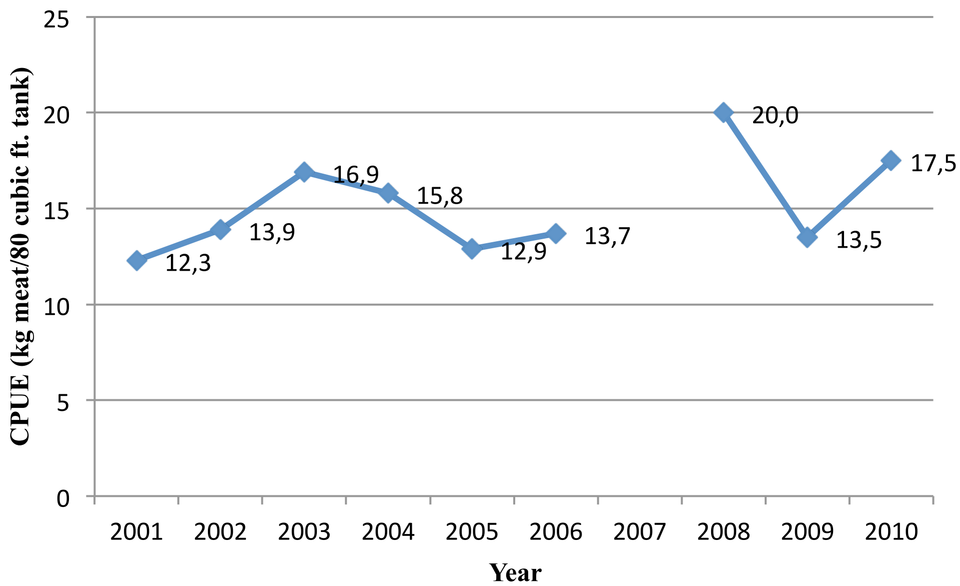

Figure 9. Catch Per Unit Effort of queen conch (kg/tank dived) over the period 2001-2010 (Horsford 2012).

CPUE estimates against tanks dived have been introduced by the Fisheries Division as a more accurate measure of catch rates since too much variability in effort is likely to exist when considering "day trip" as the unit of effort. A single "day trip" is likely to be quite varied in terms of length of trip, hours engaged in diving for conch and actual number of dives. It is also likely that fishing effort on a "day trip" may be split between diving for conch and engaging in other types of fishing activity (e.g. harvesting of lobster).

3.4 Marketing of Queen Conch in Antigua and Barbuda

Queen conch is primarily marketed locally to hotels, supermarkets, restaurants and householders. While there is some limited export to neighbouring islands and North America this has generally been on a small scale. Traditionally, fisheries exports originating from Antigua and Barbuda have been sent to the neighbouring French territories of Guadeloupe, Martinique, St. Barthelemy and Saint Martin. However, the formation of the European Union (EU) single market in 1993 and introduction of harmonised legislation governing food production resulted in significant impact to Antigua and Barbuda's fisheries export sector.

EU Directive 91/492/EEC lays out the conditions for production of live bivalve molluscs but applies equally to marine gastropods. Article 8 of the Directive concerns imports from third countries and is guided by the principle that "provisions applied to import…from third countries should be at least equivalent to those governing the production of…community products" (EEC 1991). This principle requires that countries wishing to export fisheries products into EU markets have in place health and safety protocols, fisheries management measures and technical provisions that at the very least comply with rules set out for European Union countries. For Antigua and Barbuda, this requirement for equivalency has been particularly hard to meet for queen conch. The Directive further lays out the conditions by which equivalency may be proven and requires that account be taken of legislation in the country of origin, health conditions during production and trade including monitoring of the marine environment for biotoxins and microbial contaminants. Such technical requirements make it difficult for Antigua and Barbuda to meet the standards to allow for queen conch export to the EU thus from 1997 trade in queen conch to these traditional markets plummeted to zero. Prior to 1997 export records from the Fisheries Division indicate queen conch meat exports to those markets were as high as 38 metric tonnes in 1983 and as low as 8 metric tonnes in 1992 (Figure 10). Much of the on-going work in the Fisheries Division with respect to the queen conch fishery has been geared towards regaining market access for queen conch to markets in the EU.

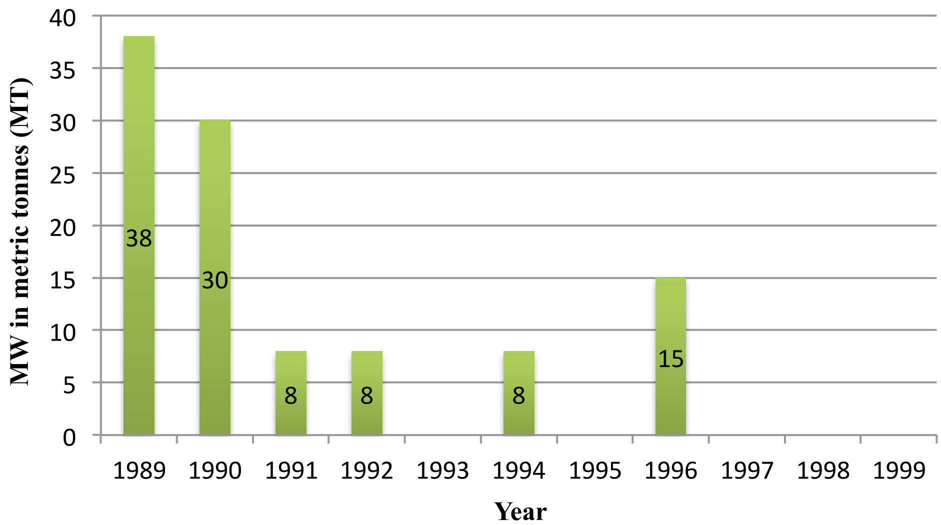

Figure 10. Export of queen conch from Antigua and Barbuda from 1989 to 1999 (Horsford 2012).

4 REGULATION AND MANAGEMENT OF QUEEN QONCH AT INTERNATIONAL, REGIONAL AND NATIONAL LEVELS

4.1 Regional and International Instruments

As a regional resource with international significance queen conch requires a multi-tiered approach to management and conservation. This means enacting a regulatory regime at the national level to achieve sustainability while establishing regional forums for information exchange and increasing knowledge. It also means enlisting the support of the international community in enforcing international trade laws. Queen conch is a highly traded resource, primarily for its meat but also for its shell, which is sold and traded as a tourist souvenir in many Caribbean countries. Due to the volume of trade, concerns were raised that this could result in long term deleterious effects to stocks in the region, prompting not only national action and regional intervention but also international attention to be placed on the species.

4.1.1 The International Regime

One of the most significant international instruments, with perhaps the greatest impact on queen conch conservation efforts is the Convention on International Trade in Endangered Species (CITES). This is an international treaty aimed at ensuring that international trade in listed species does not lead to extinction of such species. Antigua and Barbuda has been party to the CITES Convention since 1997.

Unlike regional intervention efforts, CITES is wholly concerned with aspects of international trade and does not focus on domestic utilisation of listed species. This it does by listing species on one of three appendices:

- Appendix I for species at high risk of extinction and in which commercial trade is prohibited.
- Appendix II for species that may become threatened by trade and in which commercial trade is allowed once permitting requirements are satisfied.
- Appendix III on which states may unilaterally list a species, which they feel, may be under threat due to trade.

Queen conch has been listed on Appendix II of CITES since 1992 after adoption of the proposal to do so, tabled by the United States of America. Countries commercially exporting species of flora and fauna listed on Appendix II of the Convention are required to conduct non-detriment findings. Thus authorities should only issue export permits once they are satisfied that “trade in the species will not be detrimental to the survival of the species” (CITES, 1973, Art. 4 (2)).

In order to determine whether member countries of the Convention are effectively implementing Article IV of the Convention, which deals with the regulation of trade in species listed on Appendix II, CITES may conduct a Significant Trade Review as mandated by Resolution 12.8 at the 12th Conference of the Party later revised at COP 13. If properly executed a CITES Significant Trade Review can act as a safeguard, ensuring that a species is not allowed to decline while it is listed on Appendix II (CITES, 2000). The process seeks to identify problems with the implementation of Article IV of the Convention and resolve such problems in collaboration with range states (CITES, 2000). Resolution Conf. 12.8 directs the Animals and Plants Committees in collaboration with the Secretariat and various experts to:

> *"Review the biological, trade and other relevant information on Appendix-II species subject to significant levels of trade, to identify problems and solutions concerning the implementation of Article IV, paragraphs 2 (a), 3 and 6 (a), in accordance with [an identified] procedure.*

Since its listing on Appendix II of CITES, queen conch has been subject to two significant trade reviews by that Convention. The first review was conducted in 1995 following concerns raised by the United States of America that export data was being under-reported to the Convention (Cascorbi 2004). The findings of the review were submitted to the thirteenth meeting of the Animals Committee of CITES held in 1996. The report found that there was evidence of over-exploitation and illegal trade of queen conch occurring throughout the region. In particular, concerns were raised about several countries, including Antigua and Barbuda, and their governments were given an extended deadline to respond to the concerns raised in the report. Antigua and Barbuda along with four other countries in the Eastern Caribbean failed to respond by the deadline resulting in a recommendation to suspend trade in queen conch originating from these territories.

A second review of significant trade was conducted in 2001 as ordered by the 17th meeting of the Animals Committee. Antigua and Barbuda was again listed as a country of possible concern and issued a set of long term recommended actions. These included recommendations to apply adaptive management procedures and implementation of recommendations from a CITES funded regional workshop for queen conch held in June of 2003. Failure to communicate progress to the CITES Secretariat in a timely manner resulted in a continuation of the trade suspension for several more years. This recommendation to suspend trade was lifted by the Standing Committee of CITES in 2006, as a result of Antigua and Barbuda's efforts to communicate to the Secretariat the breadth of work being conducted by the Fisheries Division to sustainably manage queen conch stocks in Antigua and Barbuda's waters and advising that trade in the species was negligible.

If Antigua and Barbuda is successful in regaining market access to the EU for trade in queen conch it will be necessary to ensure continued compliance with CITES rules concerning trade in Appendix II species in order to avoid another trade suspension. Despite having been reviewed twice by CITES there is nothing to prevent a third Significant Trade Review from being conducted for the species. It would also require compliance with the EU Directives governing import of molluscan species into the Union. Table 4 summarises requirements to be satisfied both by the CITES Convention and the EU with respect to trade of queen conch. It also includes Antigua and Barbuda's state of readiness with respect to meeting these requirements and measures being taken to achieve this. While the country is largely in compliance with most of the administrative and regulatory requirements for both entities there are some failings with regards to meeting the technical requirements. This is primarily due to limited capacity to meet these requirements. For example the requirement to monitor production areas for biotoxins is limited by the availability of testing facilities to facilitate this. Additionally, while Antigua and Barbuda undertakes fairly rigorous data collection to allow for conducting of non-detrimental findings, there is still much to be learnt about the status of the stock in Antigua and Barbuda.

Table 4. Comparative look at CITES and EU requirements to allow for the legal export of queen conch from Antigua and Barbuda and Antigua and Barbuda's readiness to comply.

	CITES Requirements	EU Requirements	Compliance	
			CITES	EU
Administrative Requirements	Designation of CITES Management and Scientific Authorities	Designation of Competent Authority	Y	Y
	Maintain records of trade	Maintain records of authorised exporting companies Approved production areas	Y	Partial
	Biannual Reports on CITES Implementation and Trade Reports		Y	
Regulatory Requirements	Issuance of export permits	Issuance of health certificates and catch certificates	Y	Y
	CITES Enabling legislation	Fisheries Management and food safety legislation	N	Y
Technical Requirements	Conduct non-detriment findings	Monitor health conditions during harvest and marketing	Partial	
	Certify species not obtained in contravention of national laws	Monitor production areas for contaminants and bio-toxins	Y	Partial

For those requirements that are not being met or only partially so, Antigua and Barbuda will need to put in some work to create an enabling environment that will allow for the revival of the queen conch export sector. Some of this work has already begun with support from international funding agencies. For instance in order to improve the Division's ability to undertake non-detriment findings the Division has received funding from the Japanese International Cooperation Agency (JICA) to undertake several studies of queen conch stocks in Antigua and Barbuda including morphometric analyses and a project to estimate stock densities in fished areas. To improve monitoring for the health and safety of fisheries products the Fisheries Division is working towards upgrading its onsite laboratory facilities, which will allow for water quality testing. With regards to the legislation, CITES enabling legislation would likely reside within another Act outside of Fisheries Division's control. The Environment Division, which serves as the CITES Management Authority has for several years been undertaking a process of drafting legislation to manage the operations of that agency. Included in the draft Environment Bill are sections on the implementation of the CITES Convention.

4.1.2 Regional Approaches to Management

Because the queen conch has such a broad distribution range, there is a recognised need for regional collaboration in its conservation and management. Medley (2008) advises that collaboration may take the form of data and information sharing and that future cooperation in queen conch management should be founded on "developing commonly accepted models for fisheries and conch biology" which could form the basis for choosing "common reference points".

In recognition of this need, a number of regional and sub-regional initiatives have been established and aimed at improving knowledge and setting a regional course of action for sustainable utilisation of the species. Queen conch has been the subject of a working group under the Western Central Atlantic Fishery Commission (WECAFC), a regional organisation under the FAO. Most recently WECAFC collaborated with several sub-regional fisheries organisations operating in the Caribbean to hold a working group meeting in Panama in October 2012. The Caribbean Fisheries Management Council (CFMC) (which represents the US territories in the United States), the CRFM, and the Central American fisheries organisation, Organización del Sector Pesquero y Acuícola de Centroamerica (OSPESCA) collaborated over two days to share information on the state of fisheries within member states and improve knowledge on the species as a whole. One of the important outputs of the Panama meeting was a Declaration, titled “The Panama Declaration”, which included recommendations to states, regional fisheries bodies and CITES (Appendix 1).

Another important initiative, which holds relevance for queen conch conservation and management, is the Protocol concerning Specially Protected Areas and Wildlife (SPAW) under the Cartagena Convention. The Cartagena Convention is a regional environmental treaty covering the Wider Caribbean including the Caribbean Sea, Gulf of Mexico and Atlantic coasts of member states. It allows for cooperation and collaboration between member countries to ensure “sound environmental management” of the Convention area. The Convention is supplemented by several protocols including SPAW, which allows for regional implementation of the Convention on Biological Diversity thus parties to the protocol are required to take measures to “protect, preserve and manage in a sustainable way” threatened or endangered species of flora and fauna occurring within their jurisdiction (UNEP, 1990, Art. 3(1)).

Queen conch is listed on Annex III of the SPAW Protocol, 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)). Antigua and Barbuda while signatory to the Cartagena Convention has signed but not ratified the SPAW protocol. However, it is likely that ratification will occur in the future.

4.2 National Management Arrangements for Queen Conch

4.2.1 National Instruments

The queen conch fishery is managed by the Fisheries Division, which is guided by the Fisheries Act of 2006 and its supporting regulations of 2013 both of which came into force on February 1, 2013. The fisheries legislation has been subject to rigorous review, starting in 2003 with the FAO Technical Cooperation Project to draft the Act and regulations and later through a series of consultations with stakeholders from across the fisheries sector.

Section 4(1) of the Fisheries Act (2006) mandates the Minister responsible for fisheries to take such measures under the Act to “promote the sustainable development and responsible management of the [fisheries] sector” as well as “ensure the optimal utilisation of…fisheries resources for the benefit of Antigua and Barbuda” (Government of Antigua Barbuda 2006). The Act also requires that the Chief Fisheries Officer (CFO) prepare and keep under review a plan “for the responsible management and sustainable development of fisheries” in the country (Government of Antigua Barbuda, 2006, Sect. 5 (1)). In developing such plans the CFO is expected to consult with local fishers, authorities and any other persons who may be affected by the plan. Elements that should be included in the plan are:

- Assessment of the present state of the fishery and its exploitation.
- Objectives to be achieved in management of the fishery.
- Management and development measures to be taken.
- Licensing programmes to be followed and limitations to be applied to local and foreign operations (where applicable) (Government of Antigua Barbuda 2006, Section 5 (3)).

In addition to these broad mandates the Act also includes provisions for the registration and licensing of both fishers and fishing vessels as well as conditions, which must be satisfied for each. The Fisheries Act and its Regulations make provisions for the declaration of Marine Protected Areas (MPAs) for the protection of key habitats, the establishment of Local Fisheries Management Authorities (LFMAs) and sets licensing requirements for all fisheries in Antigua and Barbuda. Two MPAs have been declared under the Fisheries Act. The Cades Bay Marine Reserve (CBMR) was declared under the Fisheries Act in 1999 while the Northeast Marine Management Area (NEMMA) was declared in 2005. In both cases the MPAs not only include vulnerable marine habitats such as seagrass beds (essential nursery areas for queen conch and other species) but also coastal habitats, encompassing the extent of mangrove communities that occur along the southwest and northeast coasts respectively.

In addition to the provisions set out in the Act; the Fisheries Regulations sets a number of provisions for queen conch and other species aimed at protecting juvenile life stages and spawning activity as well as set effort controls. Under sections 25 and 33 of the Fisheries Regulations both local and foreign sport-fishing vessels are prohibited from harvesting or having on board queen conch. Further, Section 32 requires that commercial fishing vessels seeking to harvest the species be required to apply for a special permit the conditions of which will be set by the CFO:

> *"…The [CFO] may limit the number of permits in order to give effect to any management programme to limit fishing effort as specified in the fisheries plan."*

(Government of Antigua Barbuda 2013)

This final provision is designed to move the fishery from the open access arrangement of the past, where any vessel licensed to operate in Antigua and Barbuda may be allowed to harvest conch, to one of limited entry. Under this regime only vessels holding a valid licence along with a special permit issued by the CFO will be allowed to target queen conch. The CFO may also attach special conditions to such permits as necessary for preservation of the stock.

Species-specific regulations for queen conch are laid out in Section 45 of the 2013 regulations establishing closed seasons and setting size restrictions for harvest. The inclusion of a two-month closure from July 1 to August 31 of each year is significant and coincides with what is known to be the peak spawning season for the species. This was a negotiated period agreed to by the commercial conch fishers. Section 45 of the regulations provides that:

> "(1) No person shall take, place for sale, purchase or have in his possession any immature queen conch (*Strombus gigas*).
> (2) The Minister shall by Notice published in the Gazette declare the close season for queen conch (*Strombus gigas)* which until otherwise declared shall commence from the 1st day of July and end on the 31st day of August of every year.

(3) No person shall fish for, take, place for sale, purchase or have in his possession queen conch (*Strombus gigas*) during the period of a closed season for queen conch.

(4) For the purposes of this regulation "immature queen conch" means -

a. a queen conch (*Strombus gigas*), the shell of which is less than 7 inches (18 centimetres) in length; or
b. a queen conch (*Strombus gigas*), the shell of which does not have a flared lip or has a flared lip of less than 1/5 inch (5 millimetres) thickness measured in the mid-lateral region; or
c. a queen conch (*Strombus gigas*), with a total MW of less than 8 ounces (225 grams) after removal of the digestive gland."

(Government of Antigua Barbuda 2013, Sect. 45)

These regulations are important as they, not only help to protect juvenile life stages and spawning activity they are also designed to ensure that adults are allowed to reproduce at least once prior to being harvested.

In Barbuda, in addition to the Fisheries Act and Regulations, the Barbuda Local Government Act guides the management of all the island's natural resources. This instrument gives authority to the local government of that island, The Barbuda Council, to administer fisheries. It also allows the local government to make by-laws governing fishing.

Finally, The Marine Areas (Enhancement and Preservation) Act 1972 is concerned with marine habitat protection and allows the Minister to declare areas of the marine environment as restricted areas. Section 3 of the Marine Areas Act provides that:

"3. (1) The Minister may by Order published in the Gazette designate any portion of the marine areas of Antigua and Barbuda as a restricted area where he considers that special steps are necessary for-

(a) preserving and enhancing the natural beauty of such areas;
(b) the protection of the flora and fauna and wrecks found in such areas;
(c) the promotion of the enjoyment by the public of such areas;
(d) the promotion of scientific study and research in respect of such areas."

Two of the country's oldest Marine Reserves were declared under this Act in 1973; Diamond Reef off North Antigua and Palaster Reef off Barbuda's South coast. In both cases the harvesting of living marine resources are strictly prohibited within the boundaries of the reserve.

4.2.2 Management Planning

The Fisheries Act (2006) provides the guiding principle that may be adopted for the overall management and conservation of the living aquatic resources in Antigua and Barbuda. Namely:

> *The promotion of sustainable development of fisheries and aquaculture activities…so as to ensure the optimum utilisation of the fisheries resources for the benefit of Antigua and Barbuda and to ensure the conservation of the fish resources and the ecosystems to which they belong.*

For particular fisheries, such as the queen conch fishery, this means not only promoting optimal utilisation of the resource but also protection of key ecosystems on which the species depend.

While the Division currently has no official management plan for the queen conch fishery, attempts have been made in past to develop management protocols for its conservation. In 2006, in preparation for regional meeting dealing the management and monitoring of queen conch resources in the Wider Caribbean, the Division developed a draft management plan. That draft document took account of the (at that time) draft Fisheries Act and Regulations and attempted to adopt a precautionary approach to management. Included in the document were eight operational objectives covering a range of issues; including health and safety, catch rates, compliance to fisheries legislation and conservation of critical habitats. These eight objectives are presented below:

- To maintain CPUE at a level that is not significantly different than the previous 10-year average until further scientific information is available on the species' status.
- To maintain capture production at a level that is not significantly different than the previous 10 year average until further scientific information is available on the status of the resource.
- To maintain depth dives at a level that is not significantly different than the mean depth of the Antigua and Barbuda shelf.
- To reduce the risk associated with decompression sickness associated with SCUBA diving through certification of all divers over five years.
- To maintain the mean five-year production value (in constant prices) per fisher at a level that is not significantly less than the previous 10 year average until further scientific information is available on the status of the resource.
- To maintain marketable MW at a level that is not significantly different than the previous 5-year average until further scientific information is available on the status of the resource.
- To maintain non-compliance levels with respect to the marketable MW at a level at or below 15%.
- To ensure certain critical habitats for conch are protected from exploitation and degradation until further scientific information is available on the status of the resource and the environment

It is interesting to note that just two years after the above objectives were set for queen conch management, the fishery failed to achieve almost every objective, CPUE rose from 91.4 kg of meat/day trip in 2006 to 118.5 kg of meat/day trip in 2008. At the same time landings almost tripled from 68.93 MT of meat landed in 2007 to 180.93 MT landed meat in 2008. As will be demonstrated in the next section compliance rate and mean weight of marketable meat declined during that same period. These results seem to illustrate that the conch fishery is relatively vulnerable to external economic impacts. Thus, in moving forward it will be necessary to work with fishers to ensure future objectives are met.

4.3 Issues with the Fishery and Compliance

As noted in Chapter 3, there is evidence to suggest that the queen conch fishery is overharvested in traditional fishing areas. This overexploitation of conch in shallow areas of the shelf has likely pushed fishers into deep-water refugia. Coupled with direct fisheries related impacts there are also concerns of external anthropogenic impacts on the species. These include the loss of important nursery and feeding habitats due to tourism activities, dredging and other unsustainable practices.

In order to protect Antigua and Barbuda's queen conch resources, national authorities engage in monitoring, control and surveillance (MCS) activities both on land and at sea. The

Division is supported by the Antigua and Barbuda Defence Force Coast Guard (ABDF CG) in MCS. Both agencies conduct routine checks of vessels found operating in the waters of Antigua and Barbuda to ensure compliance with the law. Vessels found in violation of the Act and Regulations are offered the opportunity to avoid a lengthy court case by choosing to pay a fine. Between 2002 and 2009 a total of 129 offenses were recorded in Antigua and Barbuda. The possession of undersized conch accounted for just 3.1% of all offenses compounded (Horsford 2010).

In addition to violations of size regulations, the queen conch fishery is plagued by illegal harvesting in shallow areas of the shell, by unlicensed recreational divers who generally target juveniles of the species. The recent discovery of piles of juvenile conch on Antigua's east coast points to the need for improved enforcement of queen conch regulations.

In order to observe compliance to regulatory provisions, the Division's enforcement programme is augmented by observations during data collection. The conch biological programme offers an opportunity to measure compliance to provisions of the regulations related to minimum size limits. The Fisheries Division set an informal compliance rate of 85% in 2001 as a precautionary limit for the fishery (Horsford 2010). Between 2001, when the measure started, and 2009 the fishery has fallen below this limit 3 times (Figure 11). Over that period a mean compliance rate of 88% was recorded. Perhaps not surprisingly, both mean MW and compliance rates were lowest in 2008 when fishing effort doubled as a result of new entrants to the fishery. The following year, while the mean weight of landed meat remained relatively low, the fishery recorded the highest compliance rate of 97.9%.

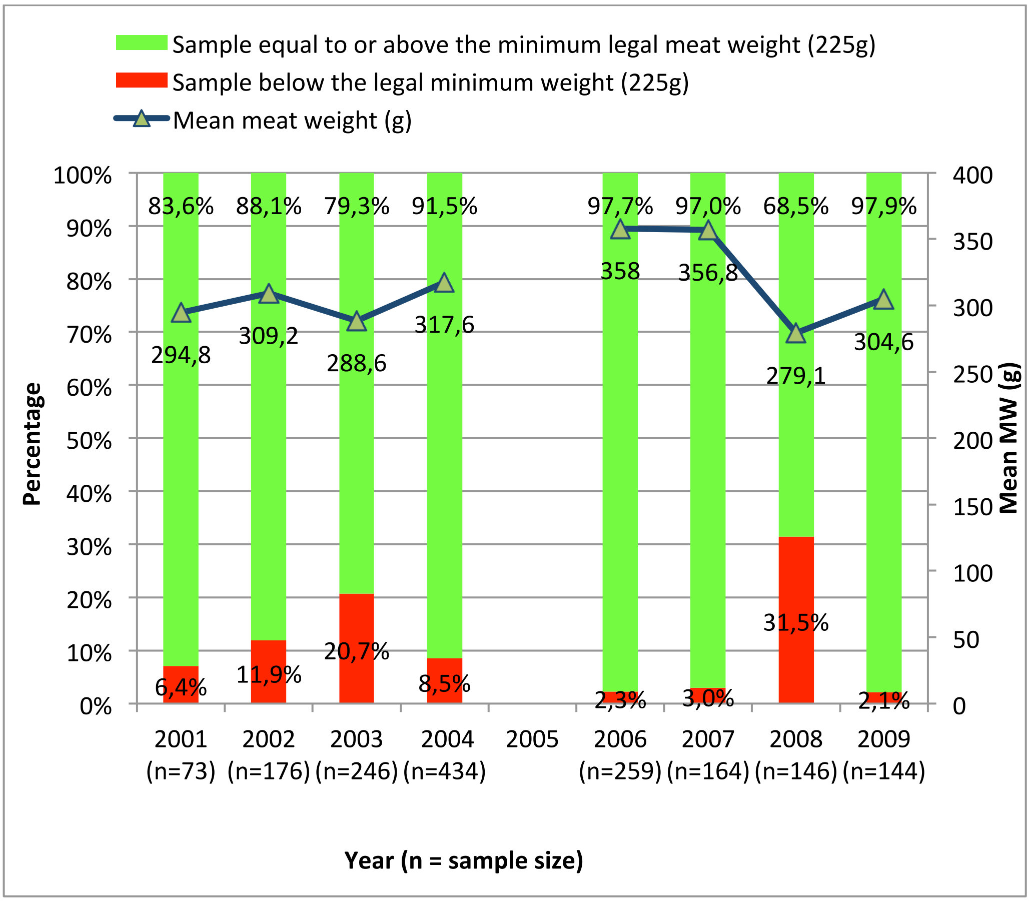

Figure 11. Rate of compliance with size limits for queen conch (Horsford 2010).

Horsford (2010) asserts that the relatively high compliance rate for the queen conch fishery is likely due to a number of factors:

- The fishery is small and relatively homogenous in nature.
- It is concentrated in the southern communities, which have demonstrated civic responsibility with regard to environmental matters.
- The participatory approach adopted by the Fisheries Division helps to build ownership in resource management.
- The on-going public awareness by the Fisheries Division.

Moving forward is a key provision of that the management framework must consider in maintaining and improving compliance rates in the fishery.

5 FISHERIES MANAGEMENT THEORY

Article 6.3 of the FAO Code of Conduct for responsible fisheries sets as one of its guiding principles that "states should prevent overfishing and excess fishing capacity and…implement management measures [that] ensure fishing…effort is commensurate with the productive capacity of the fishery resources and their sustainable utilisation" (FAO 2006). Thus, states have a responsibility to implement effective fisheries management controls as a means of protecting living aquatic resources under their jurisdiction. According to the FAO Technical Guidelines for Responsible Fisheries, fisheries management "entails a complex range of tasks [designed] to optimize benefits to resource users through [the] sustainable utilization of living aquatic resources" (FAO 1997). However, defining "sustainability" is also complex and necessitates taking a multi-dimensional view. Charles (1994) observed that in order to recognise the multiple objectives of fisheries management the concept of "sustainability" could be expressed as the simultaneous pursuit of four separate components:

- Ecological sustainability.
- Socio-economic sustainability.
- Community sustainability.
- Institutional sustainability.

Sustainability, he notes, requires "operationalizing a balancing act between present benefits and future rewards.

In traditional fisheries management theory sustainability is often measured in terms of maximum sustainable yield (MSY), representing the maximum annual of harvest that can be extracted from a resource base while maintaining the long term sustainability of the stock (Charles 1994). This measure of sustainability, however, ignores economic variables and gives no consideration to the profitability of the fishery. More recently fisheries have begun to be managed based on the maximum economic yield (MEY). Along with biological dynamics of a fishery resource, MEY explicitly considers the interest of harvesters by including a harvest function that translates effort into catch (Larkin *et al.* 2011). By estimating the net economic value of the fishery MEY recognises the crucial nature of fishing as an anthropocentric activity (Larki *et al.* 2011).

Larkin *et al.* (2011) outline several benefits associated with adopting MEY as a measure of sustainability as opposed to using only a biological measure. Firstly, they note profits are always maximized at the MEY as it occurs where the difference between cost and benefits are greatest. Secondly, it implies efficiency freeing up excess capital, which can be used in other areas of the economy. Thirdly, maximizing harvesting costs can help improve competitiveness of the fishery. Fourthly under reasonable bioeconomic assumptions MEY is usually associated with a larger equilibrium stock than MSY. The most compelling argument, they note however, is that MEY models the efficient use of resources and responds to changes in the economic conditions of the fishery.

Bioeconomic modelling is advocated as an important tool in fisheries management and for determining sustainable levels of harvest and effort (MEY) (Larkin *et al.* 2011). It allows resource managers to estimate and predict the bioeconomic impact derived from various management strategies (Seijo *et al.* 1998). By combining both economic and biological aspects of fisheries, bioeconomic models help to explain stock, catch and effort dynamics under different regimes, and can provide insight on optimal management arrangements (Larkin *et al.* 2011).

Bioeconomic theory was pioneered by Gordon and Schaefer's static model of a single species commercial fishery, which is widely used to describe and compare equilibrium solutions (Larkin *et al.* 2011). The model illustrates the economic inefficiency of an open access regime as compared to a more economically efficient outcome that maximises long term resource rents (Figure 12).

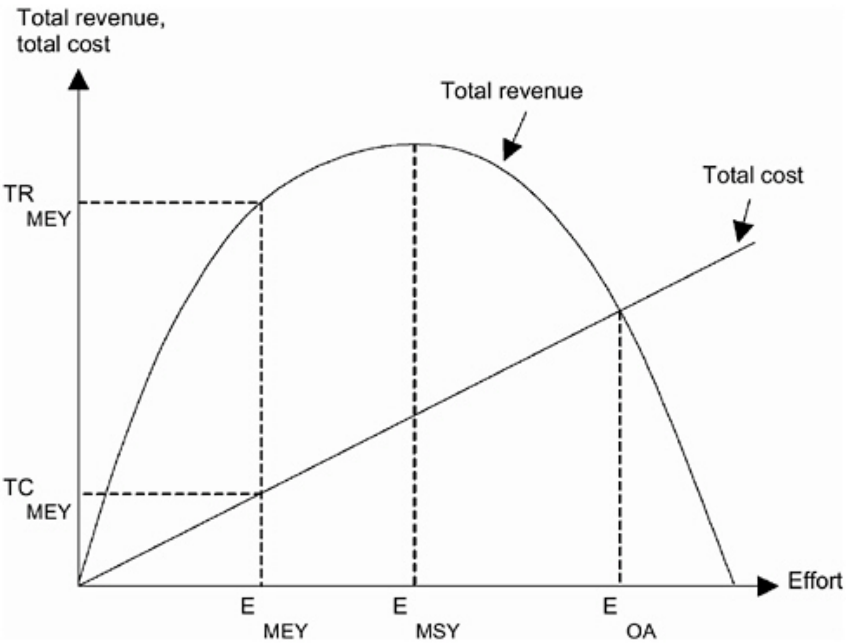

Figure 12. Two-dimensional illustration of a commercial fishery showing MSY, MEY and EY (National Research Council 2002).

In order to maintain stock biomass it is necessary to control fish mortality by regulating how much of the resource is caught, when they can be caught and at what size and age they should be harvested (FAO 1997). In fisheries management regimes, three broad types of control measures are recognised as means of maintaining sustainable stock biomass:

- Technical measures.
- Input controls.
- Output controls.

Each of these measures carries with it different implications for the fishery and effectiveness with regard to sustainability.

5.1 Technical control measures

The FAO Technical Guidelines on Fisheries Management describes technical control measures as mechanisms designed to restrict the output that can be obtained from a specified effort. They may include restrictions on gear as well as restrictions on the timing and area in which such gear may be deployed. Alternatively, measures may set limitations on specific characteristics of a particular gear (e.g. mesh limits for nets and traps). All of these technical measures are designed to control fishing mortality of components of the stock (FAO 1997); for instance mesh limits that allow juveniles to pass through the net instead of being trapped, or escape panels in certain gear to reduce by-catch of unwanted species.

In addition to directly controlling gear, technical control measures may also be employed by limiting the timing and area in which a gear is used. For instance, the establishment of closed seasons during peak spawning can help recruitment of juveniles. Similarly closing special areas may help to protect key life stages of a stock (juveniles in nursery areas). In this regard, MPAs can be important tools to fisheries management. According to Hall (2002), area and time restrictions to a fishery can help achieve sustainability by:

- Limiting the harvest of key life stages.
- Protecting depleted stocks and habitats to allow for rebuilding of a fishery.
- Protecting habitats that are critical for the sustainability of harvested resources.
- Restraining excess fleet capacity.
- Optimising the value of the catch.

While technical control measures form a crucial part of a fisheries management regime designed to control biomass loss, they may also prove ineffective if applied in isolation of other management measures. Further such measures could lead to economic inefficiencies in a fishery by limiting effort to the point that they reduce CPUE below attainable levels (FAO 1997). Thus, such measures should form part of a broader management framework.

5.2 Input Controls

Fisheries management theory suggests that if unchecked fishing effort will continue to increase until fishers make on average only marginal profit or no profit at all in a fishery (Pope 2002). Such is the case in open access regimes where fishers will continue to fish even after a fishery becomes unprofitable. This typically leads to overexploitation as fishers race to remove resources from the system that may not have even realized their full growth potential. To deal with excess capacity fisheries managers may employ input (or effort) control measures, described by Pope (2002) as "restrictions put on the intensity and [usage]" of fishing gear. These include restrictions on the number of fishing units, the amount of time units can spend fishing and on the size of vessels and/or gear (FAO 1997). In order to employ such measures managers must employ some sort of restrictive licensing scheme, which can limit the total number of entrants to a fishery as well as the fishing power of each. In situations where licensing schemes are adopted after a fishery has been overexploited Pope (2002) recommends undertaking measures to reduce capacity by:

- Removing vessels from the fleet.
- Making all vessels fish for shorter periods.
- Limiting the amount or size of gear that a vessel can carry.

- Reducing the efficiency of fishing effort (e.g. by closing areas where catch rates are high).

Input controls are more easily monitored than output measures; however fisheries managers may encounter problems in determining the amount of effort actually represented in a fishery (FAO 1997). For instance it is difficult to determine the efficiency associated with different classes of vessels or to compare the effort levels associated with different types of gear. This is even more difficult in data poor fisheries, without long time series of catches. It may also be a challenge to define a reasonable unit of fishing effort and for some there is no consistent measure to quantify effort (Pope 2002). In situations where effort controls are employed one of the main problems encountered is the increase in technical efficiency that may occur over time (Pope 2002).

Grafton *et al*. (2006) suggested that input controls increase fishing costs and often fail in their objective of limiting fishing effort. This, they note, is due to the fact that harvesters are often able to substitute unregulated inputs for controlled ones, gradually leading to an expansion of fishing effort over time.

5.3 Output Controls

Output controls are direct limitations on the amount of fish that may be removed from a fishery. These may include limitations on the tonnage or number of fish that may be caught over a given period (Total Allowable Catch) or, in the case of recreational fisheries, limitations on the amount of fish that may be caught in a day (bag limit). The employment of output controls to a fishery necessitates the estimation of the optimal catch that can be removed from a system, which requires good information on stock dynamics and its response to fishing mortality (FAO 1997).

Pope (2002) suggests that the employment of TAC limits in a fishery is designed to restrict harvest of fisheries resources to sustainable levels by limiting harvest to a safe proportion of the exploitable biomass. He notes that to be truly effective, TAC should take account of changes in biomass over time and therefore should go up or down as stock biomass increases or decreases. While estimation of stock biomass is a costly and difficult undertaking, in order to effectively implement catch (output) control schemes this must be done with precision.

Once a TAC is set it is necessary to put measures in place to ensure these limits are not exceeded. Pope (2002) recommends a number of mechanisms to achieve this:

- Free fishing until the total allowable catch is taken and then shutting the fishery down;
- Allocating catch by period and then shutting down the fishery for the remainder of each period when the allocation is caught.
- Allocating proportions of the TAC to various sectors and leaving them to manage their own share themselves.
- Allocating proportions of the TAC to individuals or individual vessels.

The simplest system would of course be to allow fishing to freely continue until the TAC is reached, however it is also the option that would encourage the "race to fish" to continue and as a result may result in the fishery exceeding the TAC (Pope 2002). In fact one of the biggest problems with using output controls is the monitoring requirement that go along with such a system to ensure catches are not exceeded. This can be a costly and demanding exercise and may be difficult to execute in small-scale fisheries. Pope (2002) suggests that by allocating portions of the overall limit as quota to individual sectors in a fishery this is likely to encourage a more orderly "uptake of the TAC" and can lead to greater economic efficiency. Grafton *et al.* (2005) suggested that in order to create incentives leading to sustainable behaviour it is necessary to provide fishers with more secure harvesting or territorial rights to fish thus enabling them to enjoy sustained benefits with an "enforceable right to exclude others from these benefits".

Medley (2008) proposes that where a TAC can be applied to queen conch fisheries and reliably controlled it should be implemented. However, limits set must be based on sound science. For queen conch, a resource highly vulnerable to overexploitation, this is especially crucial. Output control mechanisms have been applied to Jamaica's queen conch fishery, one of the largest commercial fisheries for this resource in the Wider Caribbean region and perhaps the largest in the English speaking Caribbean.

5.3.1 Case Study –NTAC System in Jamaica

Jamaica's queen conch fishery is mixed, comprising both an industrial and artisanal fleet. The fishery is based on the offshore area of Pedro Bank with virtually no fishing occurring around the island's coast due to overexploitation in those areas. The industrial fishery is a major income earner for that country, generating a substantial amount of foreign exchange earnings (Aiken *et al.* 2006). Estimates of gross earnings for the fishery range from as high as 19.5 million US dollars in 1994 when export quotas were at its highest to about 2.6 million US dollars in 2011 after reduction in export quota (Morris 2012). The fishery is the most valuable commercial fishery in Jamaica, which is encouraging considering that just a few short decades ago the conch fishery was limited to small-scale operators collecting from the island shelf stocks, which have since collapsed (Aiken *et al.* 2006).

The fishery is managed based on a National Total Allowable Catch (NTAC) coupled with biological control measures such as closed seasons. The NTAC is set based on density estimates, generated from abundance surveys. Due to concerns about overfishing in the mid-1990s there was an agreement to reduce the NTAC by 100 tonnes every year until it reached 1000 tonnes by the year 2000 (Aiken *et al.* 2006). NTACS are set annually at the beginning of the fishing season and allocated to a small number of qualified companies.

The system in Jamaica works but, unfortunately, is not impervious to failure. As late as 2006 there were fears that the fishery could be once again on the brink of collapse (Aiken *et al.* 2006). The system is also heavily reliant on accurate information on the density of conch stocks in Pedro Bank. Conch abundance surveys are conducted by the Jamaican authorities, on average, every three years, most of which are financed by the industry.

The establishment of such a system in Antigua and Barbuda would require not only significant investment in research but also extremely effective enforcement arrangements to ensure quotas were not being exceeded. Enforcement failure was identified as one area of concern for the Jamaica fishery (Aiken *et al.* 2006).

5.3.2 Property Rights Based Fisheries and Output Controls

Output controls combined with a property rights system, where users are allocated rights to harvest a resource, is perhaps one of the most effective means of achieving sustainability in fisheries. Arnason (2007) suggests that extending property rights regimes in fisheries is a flexible means of "generating economic efficiency", once such rights are of "sufficient quality". By allocating user rights in fisheries it is possible to use market mechanisms to regulate fisheries in such a way that ensures limitations on catch and on effort are achieved and utilized efficiently (Hanneson 2005).

Use rights in fisheries range widely, each carrying with it its own advantages and disadvantages. Charles (2002) describes three types of use rights:

- Customary Marine Tenure (CMT) and Territorial Use Rights in Fishing (TURFs)
- Limited entry (i.e. limitations on the number of fishers with rights to access a resource.
- Quota allocations to individuals, companies, cooperatives or communities. Such quotas may be or may not be transferable.

Both CMTs and TURFs are based on the spatial allocation of rights to groups or individuals generally, but neither is necessarily based on long standing tradition or customary rights (Charles 2011). Limited entry access rights include licensing schemes, applied to individuals or communities. Charles (2011) notes that such access rights may be extended to quantitative rights, limiting either effort or harvest.

5.4 Fisheries Management Regimes: Top-down Versus Bottom Approaches to Fisheries Management

5.4.1 Co-Management Approach to Fisheries Management

In a paper titled "The Community: The Missing Link in Fisheries Management" Jentoft (2000) proposes that "viable fish stocks require viable fisheries communities". Recognising that fishing as an activity largely draws from a common pool resource to which no one has "right" of property, involving communities in fisheries management may help to safeguard against some of the pitfalls that have resulted from more top-down fisheries management models. Jentoft (2000) goes on to note that when "self-restraint, prudence and community solidarity" become eroded and fishers no longer care about the resources, their community or each other the resulting effect is overfishing. Co-management is a viable and growing option that is widely accepted as a path to achieving sustainability in fisheries management. But what is co-management?

There is no single definition for the term co-management; however it may be broadly defined as a management arrangement that allows for cooperation and collaboration between government and communities in the management of fisheries resources. Thus it suggests a shared responsibility in management. The term community under a co-management regime need not be limited to geographical communities but may include "functional communities", a group of persons with common interests, functions or purpose. With respect to fisheries such functional communities may include fishers targeting a common resource or operating under similar conditions, fisheries scientists, and conservation groups with an interest in conserving fisheries resources. In the context of the queen conch fishery in Antigua and Barbuda, commercial conch fishers operating in the waters of Antigua and Barbuda may be considered a "functional community".

Jentoft *et al.* (1998) notes that co-management is "not a fixed unitary entity", rather it may be described as "a set of principles for institutional design that [may] assume various […] forms depending on particular circumstances". It is not as much about the rules of management as it is about the process through which rules are formed (Jentoft *et al.* 1998). Thus, it is important to understand who participates in making decisions, how debates are structured, how knowledge is used, conflicts addressed and agreements reached (Jentoft *et al.* 1998). Co-management provides a means to strengthen and or restore social integration within and among local communities (Jentoft 2000). It also requires the condition of empowerment be met. Empowerment in the context of fisheries co-management means enabling and authorising fishing communities to contribute the management of their resources (Jentoft 2005). Empowerment is achieved when it becomes possible for such communities to sustainably manage their own resources (Jentoft 2005).

Chuenpagdee and Jentoft (2007) note, however that while co-management requires community buy-in that may lead to empowerment, the process of achieving it need not be "bottom-up". In fact, in most instances initiatives aimed at achieving co-management in resource management are largely government driven. This is interesting to note in light of another reality. Jentoft (2000) points out that in many instances communities are not often ready, competent or willing to handle the responsibilities that come along with participating in a co-management system. He goes on to note that in many Caribbean countries, including Antigua and Barbuda, residents are often poorly organised beyond the household level, representing a challenge for establishing successful co-management systems.

Literature suggests that co-management may be considered along a continuum with varying arrangements and degrees of power-sharing between the community and government. Along the continuum communities may have different levels of influence and levels of participation in the management process. Figure 13 is a diagrammatic representation of the participatory continuum that exists under various co-management models.

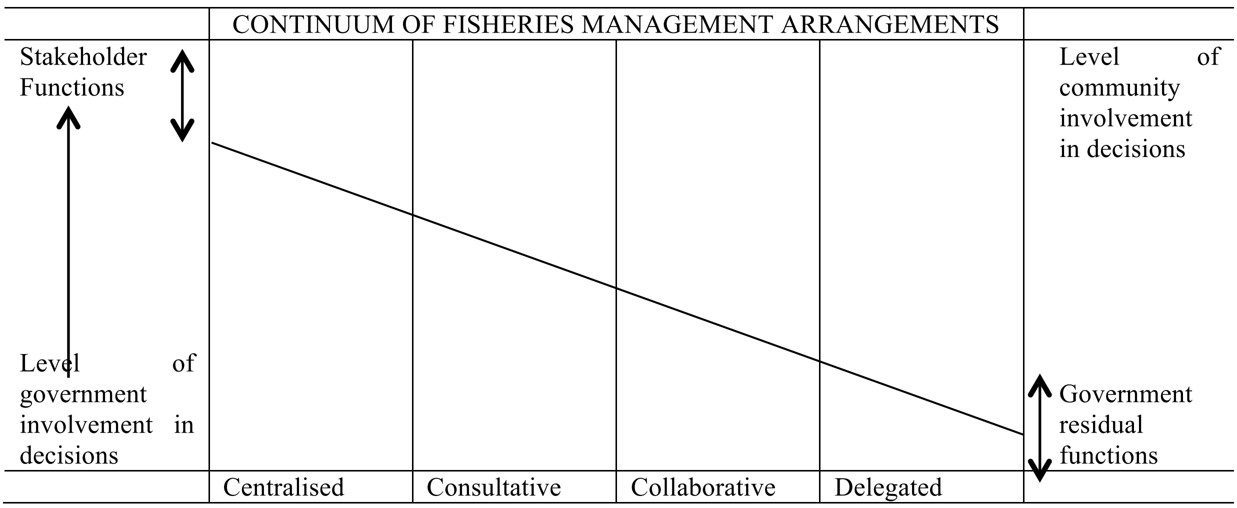

Figure 13. Diagrammatic representation of co-management (Adapted from McConney *et al.* 2003).

McConney *et al.* (2003) note that with no sharp distinction between the various types of co-management arrangements the spectrum is a continuous or scaled gradation between government-controlled, "top-down", approaches to management and community based (delegated) management. They, however, describe four broad categories of co-management. The first, consultative co-management is fairly common in the Caribbean and, as the name suggests, merely seeks the views of stakeholders (McConney *et al.* 2003). These views may or may not be taken on board by the decision makers. Collaborative co-management, suggests a more equitable sharing of management responsibilities while delegated management hands power over to communities (McConney *et al.* 2003). The diagram shows decreasing government involvement as the spectrum moves from command and control to delegated management at the same time as community involvement rises.

Implementing co-management into fisheries systems may be a lengthy and complex process, especially in situations where top-down controls dominate the management landscape. McConney *et al.* (2003) suggest a 3-phased approach to effectively implementing co-management:

- Pre-implementation, where the need for change is recognised.
- Implementation, where new co-management approaches are tested and education and awareness are built.
- Post-implementation where the best approaches are implemented and evaluation and adaptation continue.

Chuenpagdee and Jentoft (2007) considered some of the bases for implementing co-management systems into existing fisheries systems. The assessment was derived through interviews with various experts in the area of co-management from around the world. The resulting document presents somewhat of a blueprint of the key elements required for success in implementing a co-management system. At the preparatory stage, they argue, objective engagement of stakeholders is critical as stakeholders weary of the process could manipulate and stymie progress. Strengthening of collective management capabilities of communities, however, may lead to the creation of effective managers ready to resume leadership roles. Also critical is the need to "spell out" the legal process supporting co-management. Giving legitimacy to the process is key to achieving success. In the absence of a legal mandate to achieve co-management the various actors may shirk responsibilities. Central to achieving success in the process is the need to gain a thorough understanding of the local circumstances; cultures, practices and norms that exist within fishing communities. Such steps may help to prevent tensions from building due to lack of understanding at the local level. Finally, of course there must be political will, government support and funding for implementing co-management arrangements. If these do not exist, the system is bound to fail.

It must be recognised that co-management is not a panacea and success is not guaranteed. Further implementation of a co-management system does not change the fact that regulatory systems are designed to impose restrictions on users (Jentoft *et al.* 1998). It is not fixed, but an evolving process that should be guided by a set of institutional principles (Jentoft *et al.* 1998) that may vary depending on local circumstances.

5.4.2 Co-management implementation in the Caribbean

Most co-management initiatives in the Caribbean are still at the pre-implementation phase. In the case of fisheries co-management approaches few successful examples can be cited for the Caribbean region. Several attempts at fisheries co-management have been tried in various countries of the region. Most of those have been fraught with challenges and have ultimately failed. Attempts in two Caribbean islands are outlined below.

In Grenada co-management arrangements were attempted for the lobster and beach seine fisheries. In both cases they ultimately failed to move beyond the pre-implementation phase. These co-management attempts in Grenada were headed towards a consultative arrangement but ultimately it seemed neither government nor the stakeholders were ready or equipped to fully implement this new way of management. In attempting to explain this failure, McConney and Baldeo (2007) noted there was a need for fisheries managers to pay close attention to the social and cultural dimensions of their responsibility. The "human dimension" they note is essential for achieving resilient, well-nested co-management institutions.

Similarly, attempts at instituting co-management for the sea urchin fishery in Barbados saw similar challenges and ultimately never achieved true success. Parker and Pena (2006) noted that despite the daunting nature of the task of introducing co-management to Barbados' sea egg fishery, there still appears to be a general interest in seeing it fulfilled, both by fishers and the government. However, they note, this must be carefully nurtured by government officials, who will likely have to lead the process. Most of the successes in co-management in the region have been seen in the management of MPAs.

6 CO-MANAGEMENT APPROACHES IN ANTIGUA AND BARBUDA

Antigua and Barbuda, like many other countries, has a history of centralized "top-down" approach to fisheries management. However, increasingly, over the past two decades or so there has been a shift towards adopting a co-management approach to fisheries management. Provisions relevant to establishing co-management in fisheries are legislated in the 2006 Fisheries Act. The Act requires the CFO to "consult" local fisheries authorities and affected persons in formulation of management and development plans for the fisheries sector (Government of Antigua Barbuda 2006). It also allows for the appointment of a Fisheries Advisory Committee (FAC) by the Minister, which would be tasked with advising on the management and development of the sector. The first FAC was appointed in 1985 with members serving for a period of 2 years. However, since 1995 when the last FAC had completed their term there has been a failure to re-appoint a new committee (Horsford and Lay 2012), possibly due to a lack of political will to do so.

Despite this failure, however, the Fisheries Division has adopted a principle of consultation and collaboration with fishers and other relevant stakeholders to the sector. During the FAO sponsored review of the fisheries legislation several ad-hoc focus groups were formed comprising representatives from across the fishery as well as stakeholders from non-governmental organisations. These groups contributed quite significantly to the formulation of the Fisheries Act of 2006 and Fisheries Regulations (2013).

With regard to the queen conch fishery collaborative efforts have extended beyond the drafting of the Fisheries Regulations. Fishers have been actively involved in research initiatives targeting the queen conch fishery, and were a key component of the 2011/2012 conch morphometric study that was conducted by the Division. Conch divers actively participated in the research by providing samples from their commercial catches as well as providing guidance on appropriate areas for sampling.

In the absence of an appointed FAC the Fisheries Division has adopted an ad hoc collaborative approach, actively seeking the advice from fishers in formulating fisheries management arrangements. This was the process adopted during the review of the Fisheries legislation as well as in the finalisation and adoption of protected area management plans. Horsford and Lay (2012) represent the decision making process for management planning in Antigua and Barbuda as a 7 phased iterative process, which allows stakeholder involvement and feedback at several stages (Figure 14). Stakeholder input is sought very early, at the point of appraisal, an approach that is highly favoured by fishers and can be seen as empowering since they help to stare the process along.

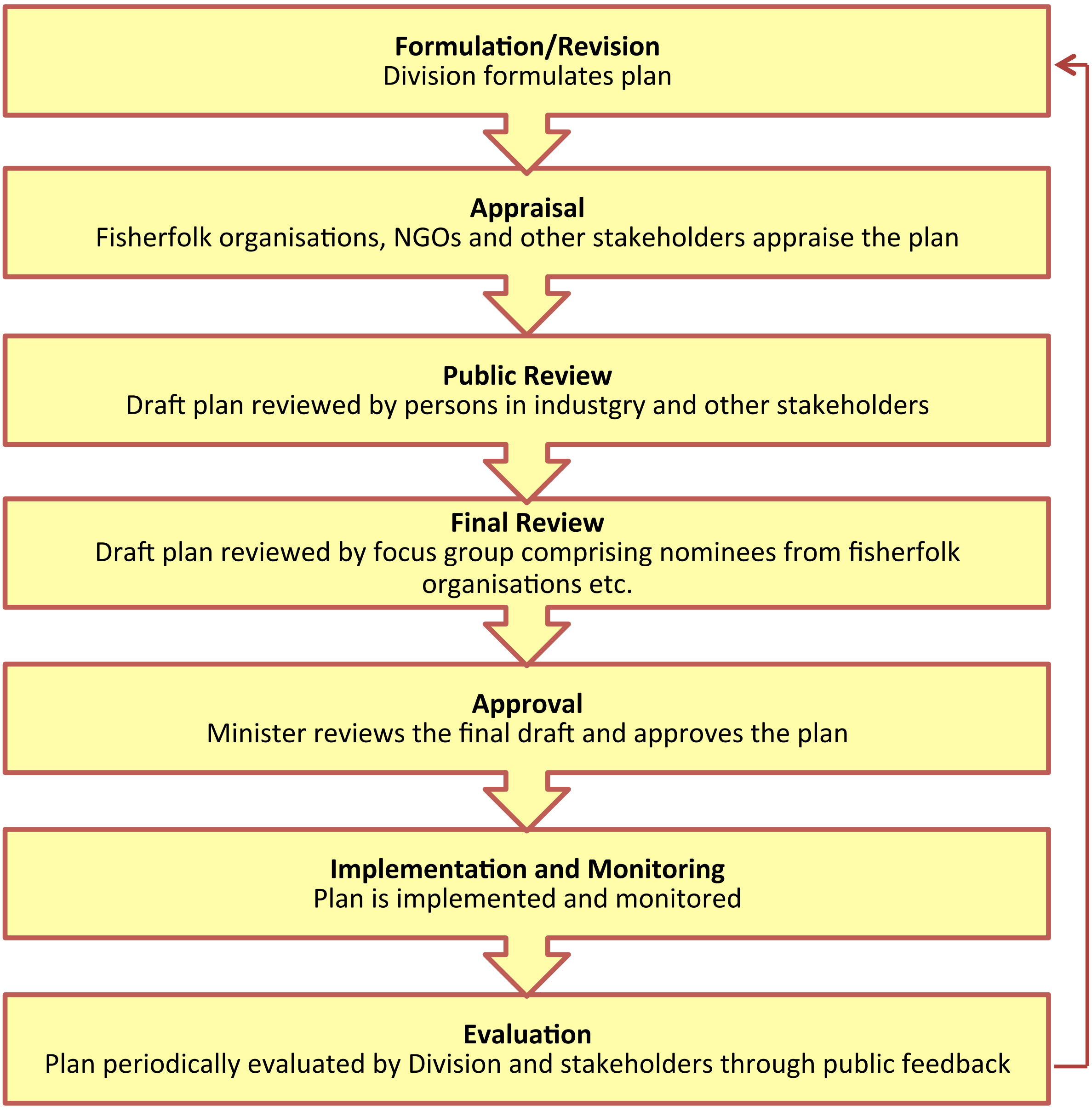

Figure 14. Participatory process in fisheries planning in Antigua and Barbuda (Horsford and Lay 2012).

For the moment the planning process is government led. However, this is largely due to a lack of strong, active fisher folk organisations that represent the broad interests of fishing communities. The lone fisher cooperative, the Antigua and Barbuda Fisher folk Cooperative Society Ltd is undergoing its own growing pains and is not well equipped to take charge of this process. For this reason it is unlikely that a co-management approach that favours delegated management would find success in Antigua and Barbuda. The current approach that is adopted by the Fisheries Division can be seen as collaborative co-management and would be likely a more successful approach.

Antigua and Barbuda may be considered to be in the early implementation phase of the co-management process. Certainly, when comparing the situation in Antigua and Barbuda to others in the region, despite it being largely ad hoc, it can be argued that Antigua and Barbuda is further along in implementation. This is because the Fisheries Division has built an environment of trust and a system of collaboration with fishers and other interest groups in the fisheries sector over a number of years.

7 BIOECONOMIC MODEL

7.1 Description of the Model Parameters

One of the objectives of the fisheries management plan will be to maximize benefits to resource users while sustaining stock levels. Thus, it is worth exploring the application of a bioeconomic model to the queen conch fishery. A simple bioeconomic model is presented here, however since many of the parameters are not accurately measured and are largely estimated or extrapolated from other fisheries it should be viewed only as a guide of what the fishery may look like and not necessarily an accurate representation of the current state. Similarly, the results of the model should be interpreted cautiously. As far as possible, accurate and available data will be included in the model. The outcome will help to identify data gaps for the fishery.

The basic programme, designed by Dr. Ragnar Aranson, is an Excel based model that calculates the equilibrium profit maximizing fisheries policies, given the user's specifications of a fishery and compares the outcomes to an open access system. The outcomes are listed in terms of profits, rents biomass, harvest and fishing effort. The inputs into the model are relatively few and include both biological and fisheries data. It is based on an aggregative model containing:

- A biomass growth function: $\dot{x} = G(x) - y$
- A harvesting function: $y = Y(e, x)$; and
- A profit function: $\pi = p \cdot Y(e, x) - C(e)$

The model includes five variables; x (biomass), y (harvest), e (effort), π (profit) and p (price). The first four are endogenous to the fishery, and the fifth, price, is exogenous and therefore determined by market conditions outside the fishery. The derivative, $\dot{x} = \delta x/\delta t$ measures the change in biomass at a point in time.

Three elementary functions are contained in the model; a natural growth function, $G(x)$, a harvesting function $Y(e, x)$, and the cost function, $C(e)$. For biomass two alternatives are considered; a logistic function ($G(x) = \alpha \cdot x - \beta \cdot x^2$) and a Fox function ($G(x) = \alpha \cdot x - \beta \cdot ln(x) - y$). A generalised Schaefer (1954) harvesting function is used $Y(e, x) = q \cdot e \cdot x^b$; where the coefficient b indicates the degree of schooling behaviour by the fish (normally $b \in [0,1]$). The cost function used is also a relatively simple one ($C(e) = c \cdot e + fk$) ; where fk represents fixed costs. Thus, the complete model is represented by the following equations:

1. Biomass growth function: $G(x) = \alpha \cdot x - \beta \cdot x^2$ or $G(x) = \alpha \cdot x - \beta \cdot ln(x) - y$
2. Harvesting function: $y = q \cdot e \cdot x^b$
3. Profit function: $\pi = p \cdot y - c \cdot e - fk$

The last two equations can be combined to yield a simpler version of the model:

4. $\pi = p \cdot y - (\frac{c}{q}) \cdot e^{-1} - fk$

Neither marginal costs (*c)* nor catchability (*q)* plays an independent role in the model. Rather, a ratio of the two variables can be regarded as a single parameter (i.e. normalized marginal cost). In the model fisheries rents are defined as $\pi_y \cdot y$. Thus, for the "specific fisheries model", rents are defined as:

5. $R = \pi + fk$

A full list of required inputs is outlined below as well as notes on their availability, reliability and possible proxies in cases where the data are lacking.

Maximum Sustainable Yield (MSY)

Two estimates of MSY exist for the conch fishery in Antigua and Barbuda. Both of these are relatively old and neither is based on rigorous scientific research but has been estimated based on survey results on other islands. Both estimates should be treated with caution. The first estimate of MSY was derived from estimates by Wood and Olsen (1983) for the United States Virgin Islands (USVI) queen conch stocks. Based on surveys conducted in the USVI Goodwin *et al.* (1985) assumed a potential conch yield of 90 kg/km^2 for the countries of the eastern Caribbean and extrapolated this number for the Antigua and Barbuda shelf, yielding an MSY estimate of 306 MT.

A second MSY estimate for Antigua and Barbuda's queen conch stock was developed in 1990 by the FAO. This estimate was again based on USVI estimates developed by Appeldoorn (1987). In this instance a potential yield value of 0.06 t/km^2 was extrapolated for the islands of the Lesser Antilles, resulting in an MSY estimate of 214 MT for Antigua and Barbuda (Mahon 1990).

Virgin Stock Biomass

Virgin biomass represents the biomass of a stock that has not been subject to exploitation. It is used as a relative measure to determine the current health of fish stocks and is an important parameter in determining MSY estimates. Unfortunately, there is no available estimate of virgin stock biomass for Antigua and Barbuda's queen conch stock. However, in the Wider Caribbean a number of research projects have focused on estimating queen conch densities in protected areas. For example in 2000 a study by Tewfik and Béné (2000) on conch densities in protected areas of the Turks and Caicos Islands yielded conch densities from 259 conch per hectare in sandy areas to 2162 conch per hectare in algal plains. Another study in fished and unfished populations of queen conch in the Bahamas found adult conch densities ranging from a low of 1.7 adults per hectare in fished areas to a high of 53.6 adults per hectare in unfished areas (Stoner and Ray 1996).

Studies such as these will be used as a measure to estimate virgin stock biomass for the Antigua Barbuda shelf. Using an estimate of 0.3 kg for average conch MW in Antigua and Barbuda, high and low end estimates of virgin stock biomass will be calculated based on two density estimates extrapolated over the Antigua and Barbuda shelf (3,400 km^2). These are rough estimates of biomass and are likely not representative of Antigua and Barbuda stock. Further the method of extrapolation assumes uniform densities throughout the entire shelf, taking no account of habitat suitability. This assumption, however, is faulty, as it is known that queen conch aggregate in higher densities in algal plains than in other substrate types.

Biomass Growth

The model requires an estimate for biomass growth in the base year t*. In addition to virgin stock biomass, this parameter has the greatest uncertainty associated with it since no estimates of biomass growth exist for the conch population in Antigua and Barbuda. According to CFMC and CFRAMP (1999), growth rate estimates for queen conch populations' range from 0.2 to 0.7 per year. Taking this uncertainty into account, a sensitivity analysis is conducted for the fishery. The primary results presented for the model will assume a growth rate of 0. This will be followed by analyses of the fishery assuming both negative and positive population growth rates at -0.7, -.05, -0.2, 0, 0.2, 0.5 and 0.7. These will be compared to varying profit ratios from 10% up to 60%.

Schooling Parameter
In the model "schooling parameter" is used to represent the amount of schooling behaviour exhibited by fish stocks. This is a number between 0 and 1. Schooling behaviour is not generally a term associated with sedentary species such as queen conch, however it is known that the species is not necessarily uniformly distributed in fishing grounds and is known to exhibit preferences for certain habitats as well as aggregate as juveniles and adults. For this reason the species is assigned a schooling parameter of 0.9.

Elasticity of Demand
Elasticity of demand measures the elasticity (or responsiveness) of fish prices with regard to changes in biomass. For the purpose of this exercise this will be removed from the model and has been set at zero.

Fisheries Data: Effort, Landings and Price of Landings
Estimates are available for queen conch landings and effort up to 2010 and are presented in Chapter 3. The 2010 figures will be entered into the model.

Costs and Profits
Specific cost estimates for the queen conch fishery were unavailable; however FAO (2001) estimated fixed and operational costs for similar vessels engaged in trap fishing in Antigua and Barbuda. These cost estimates were used to estimate costs associated with the conch fishery. Because the estimates were dated, they were adjusted for inflation using changes in consumer price index (CPI) between 2001 and 2010 as reported by the Eastern Caribbean Central Bank (ECCB). According to the ECCB (2012) the CPI increased by an average of 26.57% from 2001 to 2010. CPI for fuel and light showed the highest rate of change for that period, rising 72.60% between 2001 and 2010. "Service was assumed to represent labour costs and was seen to rise by 52.56% between 2001 and 2010. Finally for all other costs not specifically registered among the ECCB statistics the CPI associated with "all items" was used to estimate inflation. Between 2001 and 2010 the CPI for "all goods" rose by 27.88%.

All calculations associated with running costs are presented in Appendix 2. Relevant running costs for the fishery include fuel, lubricant, food, labour, general expenses and the cost of filling SCUBA tanks. The cost of filling SCUBA tanks was not considered in the 2001 study, therefore only an estimate for 2010 is presented in the table. The 2001 study assumed vessels were engaged in fishing for 120 days in the case of open vessels and 104 days in the case of fibreglass launches. Based on the data presented for the conch fishery in 2010 it is known that vessels engaged in fishing, on average, for 64 days out of the year. As a result it was necessary to first convert the costs per vessel over 120 fishing days to daily costs before adjusting for inflation and estimating these figures for 64 fishing days in 2010. Table 5 presents a comparison between operating costs for open vessels and pirogues between 2001 and 2010. In 2010, there were 13 open pirogues in the fishery and 6 fibreglass launches. Once the per-vessel cost was calculated for 2010, the figures were raised by simply multiplying by the number of vessels in each class.

Table 5. Total costs, revenue and profit (XCD) for all vessels operating in the queen conch fishery (Adapted from FAO 2001).

Open Vessel			
		2001	***2010***
Variable Costs	Running Costs	15,662.92	34,087.84
	Repairs and Maintenance	934.61	1425.85
	Insurance	201.05	2,57.10
Fixed Costs	Interest	926.46	1,184.76
	Depreciation	5,460.97	6,983.49
Totals	*Total/vessel*	*23,295.02*	*43,939.04*
	Total 2010 Costs for all Open Vessels Before License fees (X 13)		***571,207.52***
	Total Cost of Licensing All 2010 Open Vessels		***1,790.00***
	Total 2010 Operating Costs Including License Fee		***572,997.52***
Fibreglass Launch			
Variable Costs	Running Costs	40,096.01	75,007.28
	Repairs and Maintenance	8,846.23	13,495.80
	Insurance	2089.3	2,671.79
Fixed Costs	Interest	7,264.99	9,290.47
	Depreciation	24,044.57	30,748.19
Totals	*Total/vessel*	*82,341.10*	*131,213.53*
	Total 2010 Costs for all Launches Less License (X 6)		***787,281.18***
	Total Cost of Licensing All 2010 Launches		***1,185.00***
	Total 2010 Operating Costs Including License Fee		***788,466.18***
TOTAL 2010 COSTS FOR THE FISHERY			**1,361,463.70**
TOTAL REVENUES IN 2010			**2,133,409.00**
ESTIMATED PROFIT			**771, 945.30**

7.2 Results of the Bioeconomic assessment

The bioeconomic model presents outputs both with a graphical representation of the fishery as well as through quantitative estimates of various parameters at optimisation. This it does both for the logistic growth and fox growth functions. For the purpose of this analysis only the major results of the logistic growth function will be discussed for high and low end estimates of biomass and MSY. Medley (2008) suggests that the logistic (Schaefer) population model may be the most appropriate for queen conch fisheries.

7.2.1 Results for High End Estimates.

The high end estimates of biomass and MSY used in the model were 10, 000 MT and 306 MT respectively. The first (Figure 15) represents the fishery in terms of harvest (yield) as a function of biomass with a set of iso (or equi-) profit curves. Figure 16 presents sustainable costs and revenues as functions of effort, as calculated through the logistic growth function. All result tables are presented in Appendix 3. The information presented indicates that the fishery is currently operating beyond its optimal level. According to the model profit is optimsed for the fishery when biomass levels reach 5,236 MT while current levels stand at 917.5 MT, suggesting overexploitation. This overexploitation is likey caused by over capacity in the fishery as demonstrated in Figure 16. In 2010 effort levels for the fishery stood at 1, 207 fishing days. According to the model, this represents open access equilibrium at twice the optimal limit of effort (Figure 16). The model suggests that profit is optimised at an effort level of just over 750 fishing days.

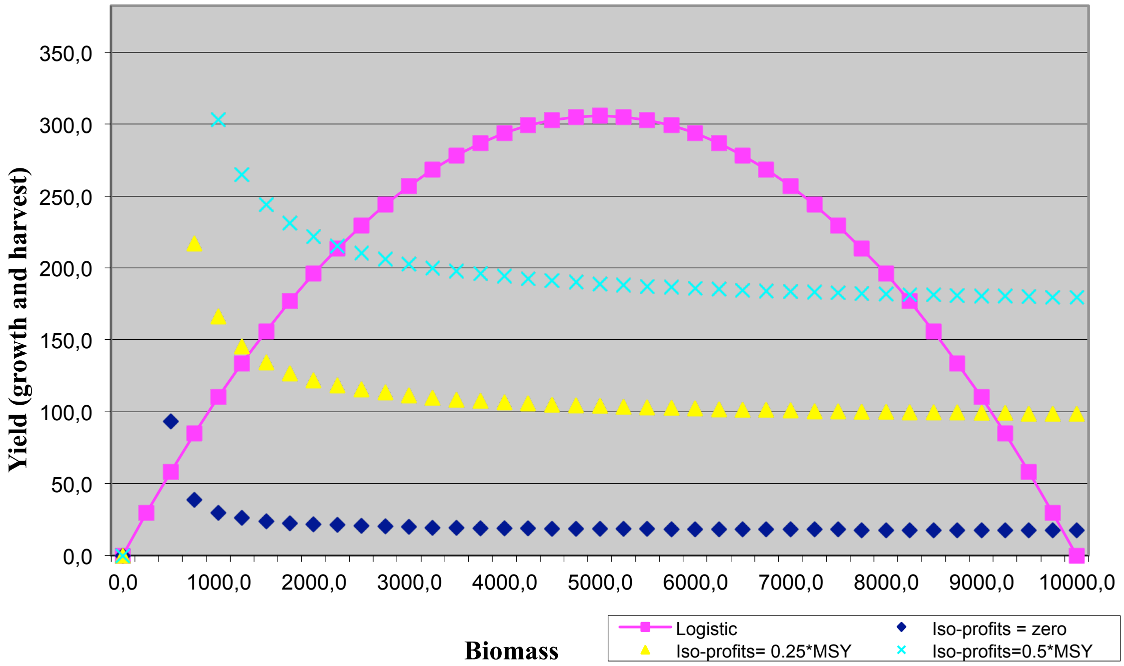

Figure 15. Logistic iso (equi-) profit curves - High End Estimates.

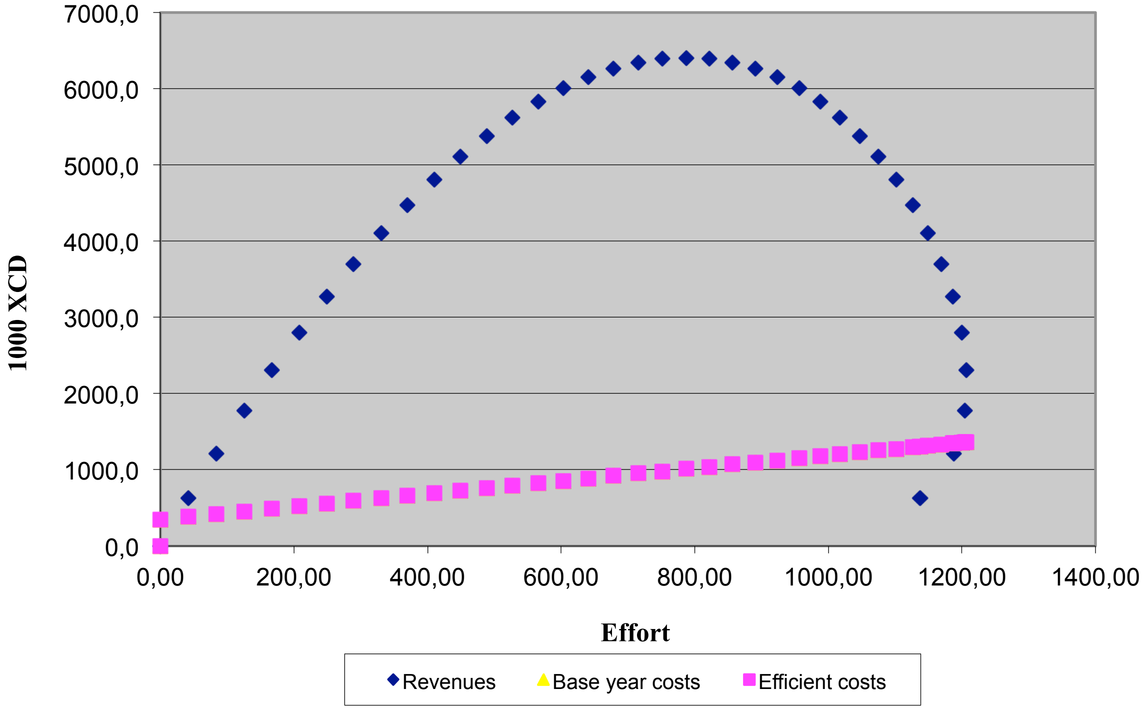

Figure 16. Sustainable revenues and costs as functions of effort - high end estimates (Backward bending part of sustainable revenues is unstable).

7.2.2 Results for Low End Estimates

The low end estimates used for biomass and MSY in the model were 1,000 MT and 214 MT respectively. As in the case above the main results assumed a biomass growth of zero. Not surprisingly these results also indicate that the fishery is currently operating at unsustainable levels and points to the need to reduce effort. Once again two figures are presented representing various aspects of the fishery. Figure 17 shows the logistic growth function with iso (equi-) profit curves, while Figures 18 again represents sustainable cost and revenue as functions effort. As was the case in analysing the results for the high end estimates, the model suggests that the fishery is operating at open access equilibrium with excess capacity. Therefore, in order to optimise profits, effort would have to be reduced. Figure 18 indicates that profits are optimised when fishing effort is approximate 750 fishing days.

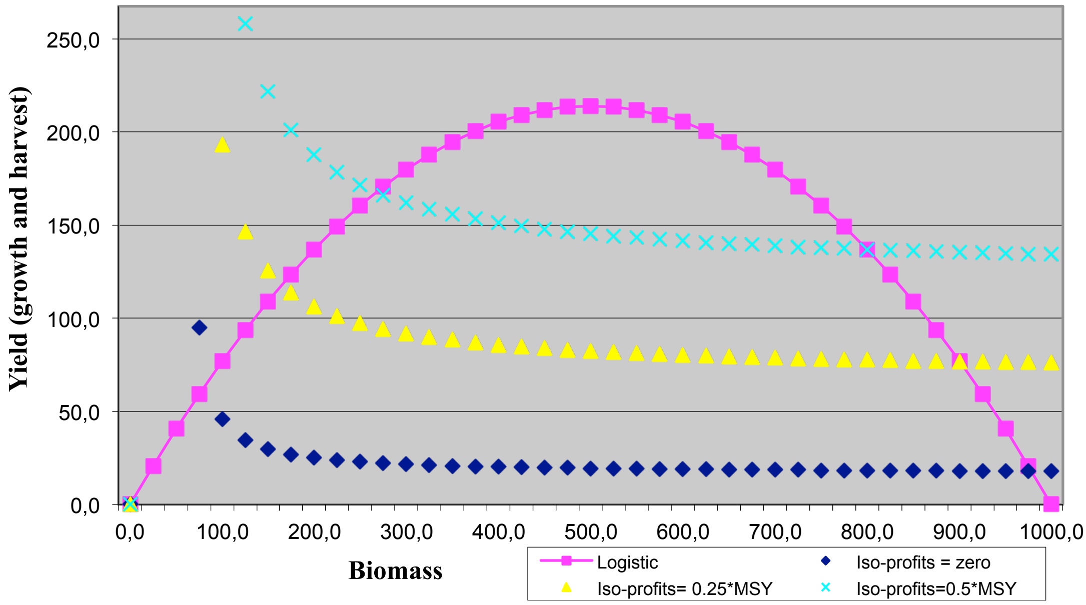

Figure 17. Logistic iso (equi-) profit curves - Low End Estimates.

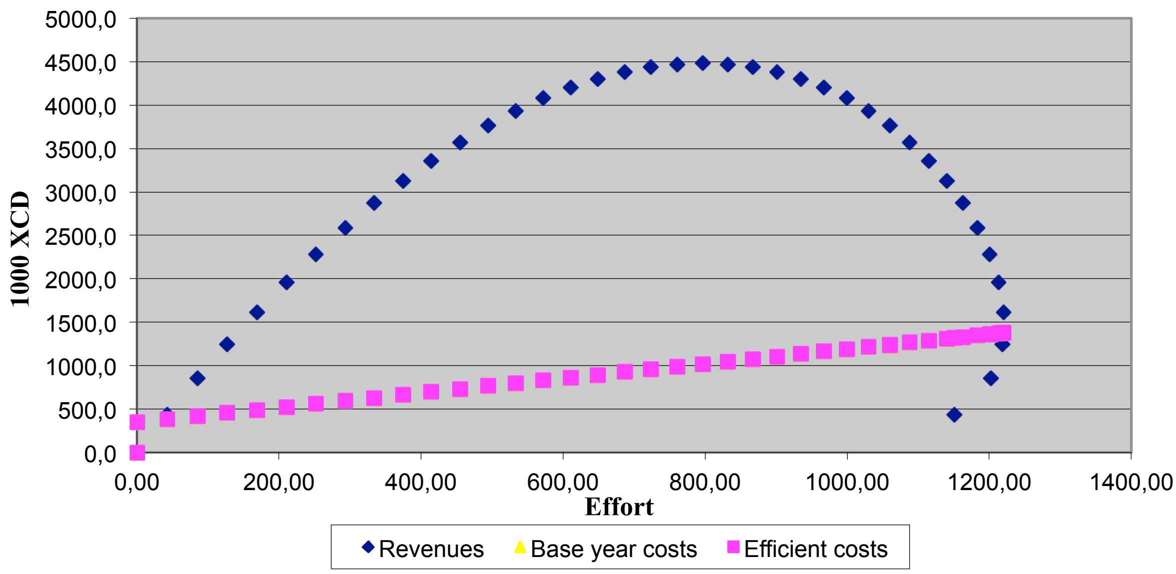

Figure 18. Sustainable revenues and costs as functions of effort - low end estimates. (Backward bending part of revenues is unsustainable).

7.2.3 Sensitivity Analysis

Because of the substantial data gaps that exists for this fishery, the model has associated with it some degree of uncertainty. Recognising this uncertainty, sensitivity analyses were conducted to determine whether variations in profit and biomass growth rate would impact the results of the model. These analyses were conducted for both the high and low end estimates of MSY and biomass. The outcomes of these tests with regard to the level of effort at which profit is maximised are presented in Tables 6 and 7 below for the logistic growth model. Table 6 presents the results for the high end estimates while Table 7 shows results of low end estimates. 36% represents the actual profit as a percentage of revenue.

Table 6. Results of sensitivity analysis for high-end estimates of biomass and MSY using the logistic growth model.

		Growth rate						
		-0.7	**-0.5**	**-0.2**	**0**	**0.2**	**0.5**	**0.7**
% Profit	**20%**	740	741	743	745	746	748	750
	30%	745	747	749	750	752	754	755
	36%	***749***	***750***	***752***	***754***	***756***	***757***	***759***
	40%	751	752	754	756	757	759	761
	50%	756	757	760	761	762	765	766
	60%	761	763	765	766	768	770	771

Table 7. Results of sensitivity analysis for low-end estimates of biomass and MSY using the logistic growth model.

		Growth rate						
		-0.7	**-0.5**	**-0.2**	**0**	**0.2**	**0.5**	**0.7**
% Profit	**20%**	729	730	732	734	735	737	738
	30%	737	738	740	742	743	745	747
	36%	***742***	***743***	***745***	*747*	***748***	***750***	***752***
	40%	745	746	748	750	751	753	755
	50%	752	754	756	758	759	761	763
	60%	760	762	764	766	767	769	771

In both the high and low end estimates, the sensitivity analysis appears to yield fairly consistent results across all parameters, pointing to the need to reduce effort. The level of reduction, however, is dependent upon assumptions regarding population growth and profit. It is also dependent on whether the high end estimates of biomass and MSY are used as opposed to the low end estimates. In the case of the high end estimates, the model suggests optimal fishing effort ranging from 740 to 771 fishing days. Similary, for the low end estimates, optimal effort ranges between 729 and 771 fishing days. As would be expected optimal fishing effort increases with increasing profit and population growth. This is the case regardless of whether the high end or low end estimates of biomass are considered. Thus, despite the uncertainty in some of the parameters used, the model is relatively consistent in its conclusions; effort must be reduced to optimise profit.

8 MANAGEMENT PLAN

Presented below is a framework management plan for Antigua and Barbuda's queen conch fishery utilising a co-management approach.

8.1 Scope of the Plan

The fisheries management plan covers the commercial fishery for queen conch in the waters of Antigua and Barbuda. The plan shall be valid for a period of five years after which it will be subject for review. The review of the plan will be based upon the best scientific information available for the species. It will also take into consideration regional and sub-regional efforts to harmonise management approaches.

8.2 Goals and Objectives

The queen conch fishery in Antigua and Barbuda will be managed in such a way as to achieve the following overall goal:

> *"Ensure the sustainable harvest of queen conch resources in Antigua and Barbuda's waters through the adoption of a participatory approach to management while maximising economic and social benefits to fishing communities engaged therein".*

In order to achieve this goal it will be necessary to fulfil a number of strategic objectives that satisfy biological, scientific and socioeconomic considerations. These objectives and resulting management measures to be employed will take into account signals on fishery health that have been alluded to by the results of the bioeconomic model. The exercise of completing the bioeconomic model also revealed data and information gaps that need to be addressed urgently to achieve long-term sustainability of the fishery.

Seven key objectives for the queen conch fishery will be addressed in the management plan:

- Optimise economic benefits to conch fishing communities without leading to irreversible impacts to the stock.
- Ensure measures are in place to protect key life stages; in particular juveniles and spawning adults through the protection of key habitats and spawning activity.
- Minimise external impacts on stocks associated with broader environmental changes (e.g. land-based sources of pollution).
- Address data gaps in the fishery:
    - To allow for improvement in bioeconomic modelling of the fishery.
    - To gain a better understanding of queen conch densities throughout the Antigua and Barbuda shelf.
    - To allow for estimates of abundance, MSY and MEY for the queen conch fishery.
- Address marketing requirements to allow for regaining of export markets for queen conch.
- Maintain Compliance rates to fisheries provisions for the species above 85%.
- Adopt mechanisms to allow for a participatory approach to promote compliance with key management arrangements contained in the plan.

Table 8 presents the proposed management strategies and key performance indicators to help meet management objectives.

Table 8. Proposed management strategies and performance indicators for achieving fisheries management objectives.

Objective	**Proposed Management Strategy**	**Key Performance Indicators**
Optimise economic benefits to conch fishing communities without leading to irreversible impacts to the stock	– Effect measures to reduce fishing effort to pre-2008 levels through permitting scheme	– Effort levels – Production levels – Profits to the fishery
Ensure measures are in place to protect key life stages; in particular juveniles and spawning adults through the protection of key habitats and spawning activity	– Implement provisions of the regulations regarding closed seasons – MPA planning to include seagrass communities and algal beds in MPA network – Implement existing MPA management plans	– Compliance to closed season measures – Compliance with measures regarding closed areas
Minimise external impacts on stocks associated with broader environmental changes (e.g. land-based sources of pollution)	– Seek to include fisheries management considerations in broader planning arrangements	– Adherence of planning authorities to fisheries advice regarding development in coastal areas
Address data gaps in the fishery: – To allow for improvement in bioeconomic modelling of the fishery – To gain a better understanding of queen conch densities throughout the Antigua and Barbuda shelf – To allow for estimates of abundance, MSY and MEY for the queen conch fishery	– Improve Data Collection activities to capture key biological and economic data – Undertake research to improve knowledge on stock structure of	– Implementation of improved data collection protocols – Fisheries research undertaken – Utilisation of improved data in stock assessment models
Address marketing requirements to allow for regaining of export markets for queen conch	– Improve facilities for water quality and ciguatoxins testing – Enact fisheries management and CITES legislation	– Passage of CITES legislation – Implementation of Fisheries legislation – Laboratory reports
Maintain Compliance rates to fisheries provisions for the species above 85%	– Continue monitoring of landings – Public awareness and user buy-in through co-management approach	– Improved compliance to fisheries legislation
Adoption of mechanisms to allow for a participatory approach to promote compliance with key management arrangements contained in the plan	– Formalise adoption of review procedure for fisheries planning – Engage conch fishers and other key stakeholders in finalisation of the plan – Explore mechanisms for the creation conch fishers group	– Stakeholder participation in consultations

8.2.1 Objective 1: Optimise Benefits to Conch Fishing Communities

Despite the uncertainties associated with the bioeconomic model, both the base model and sensitivity analyses indicate that optimisation of economic benefits necessitates a reduction in fishing effort from ca. 1200 fishing days to ca. 750 fishing days. In light of previous recommendations for the fishery by Horsford (2006) that suggested maintaining effort and CPUE at precautionary limits not exceeding mean levels observed prior 2008, the proposed management strategy is to reduce fishing effort. This strategy may be implemented under the 2013 Fisheries Regulations, which provides that fishers must be in possession of a special permit to harvest queen conch. The Regulations also provide that the CFO may limit the number of permits that may be issued.

In order to determine whether this management objective is being met a number of key performance indicators may be. These include production and effort levels, as well as profits generated from the fishery.

8.2.2 Objective 2: Measures to Protect Key Life Stages

Achieving sustainable fisheries requires that stocks are able to replenish biodiversity loss caused by fishing mortality. For sedentary, slow growing species like queen conch, which are highly vulnerable to overexploitation this is even more critical. Thus it is necessary to protect key life stages such as juveniles and spawning adults and important life processes such as spawning activity.

To achieve this objective, two key provisions of the Fisheries Regulations are critical and must be enforced:

- Establishment of a closed season for queen conch during peak spawning activity.
- Establishment of MPAs that include important habitats for juveniles.

Several MPAs have already been declared under the Fisheries Act and at least two of them include key habitats such as sea grass beds. The provision of establishing a closed season has never been implemented in Antigua and Barbuda. Thus careful consideration and planning must be made to determine how best to enforce it.

In order to determine whether this objective is being met the key performance indicators that should be used are compliance to closed season and closed area regulations. This can be monitored through on-going enforcement activities.

8.2.3 Objective 3: Minimise External Impacts to Queen Conch Resources

This particular objective is one that cannot be met by the Fisheries Division alone. It requires the participation of fishers as well as other key agencies in government. A range of activities external to fishery may impact queen conch populations, including destruction/alteration of habitat and climate change. Ensuring conch populations are cushioned from such external impacts is critical to ensuring stock recruitment and long term sustainability.

To achieve this objective the management strategy proposed is one that is already being used by government; the inclusion of fisheries concerns in wider developmental planning. The key performance indicator for this objective is getting some measure of how well planning agencies incorporate fisheries recommendations into approval conditions for coastal development projects.

8.2.4 Objective 4: Address information gaps

As has been shown there is an urgent need to increase the scientific knowledge of Antigua and Barbuda's queen conch stock in order to improve its management. This is particularly true for newer fishing grounds where very limited research has been undertaken. Although no negative trends in CPUE have been recorded for the queen conch fishery researchers agree that, for species like queen conch, CPUE is not always an accurate measure for assessing biomass (Ehrhardt and Valle-Esquivel 2008, Tewfik *et al.* 2001, Hilborn and Walters 1992, Arreguin-Sanchez 1996). This can only be assured by conducting rigorous surveys to estimate abundance.

The data gap that exists for the fishery may be divided into two areas, scientific/biological data and socio-economic data.

Scientific/Biological Data
From the data amassed for the queen conch fishery there are indications that stock health for queen conch is variable across the Antigua and Barbuda shelf. The fact that fishers were forced to begin harvesting the resource outside of their traditional fishing area seems to corroborate this. However, there is a need to undertake a thorough assessment of queen conch populations, both in commercial fishing grounds and unfished areas of the shelf to confirm these assertions. Among the information required allowing for better understanding of the species' conservation status:

- Density estimates for traditional areas, new commercial grounds and unfished areas.
- Information on important aggregations of the species if such exist to inform protected area planning.
- Extrapolations of conch abundance estimates for the entire shelf.
- Research to determine Maximum sustainable yield estimates.
- Population growth estimates, which may be garnered through continued monitoring of the resource.

Socio-economic Data
The amassing of key socio-economic data for the queen conch fishery will help to improve assessments regarding its profitability. To date no thorough assessment has been undertaken of the real operational costs associated with Antigua and Barbuda's queen conch fishery. The Division attempts to capture some of this data through its routine data collection activities; however the information is quite limited and does not include some of the more important costs such as labour and maintenance. To improve knowledge on the fishery's profitability it will be necessary to work towards gathering information on the following key economic costs in the fishery:

- Running Costs per trip
    - Fuel.
    - Supplies.
    - Labour.
- General operational costs
    - Maintenance.
    - Insurance.
- Interest.

- Depreciation.

This information will allow for more refined bioeconomic modelling of the fishery and will assist in determining effort levels that will lead to the optimisation of profits.

To address this objective a number of key management strategies will be employed including; (1) registering improvements in the data collection system to allow for capturing economic data along with the catch and effort data currently being collected and (2) conducting research to allow for accurate density and abundance estimate for Antigua and Barbuda's queen conch population. To achieve the latter objective it may be necessary to source external funding as has been done in the past from agencies such as FAO and JICA.

Performance indicators for this objective include the rolling out of improved data collection techniques, execution of research activities and the inclusion of improved data in fisheries assessment models

8.2.5 Objective 5: Address Marketing Requirements

Both the Fisheries Division and commercial conch fishers are interested in regaining access to traditional export markets of the EU for queen conch. This necessitates not only adhering to EU provisions regarding equivalency but it also requires meeting requirements under the CITES Convention. Laboratory upgrades to facilities at the Fisheries Division, will in the long-term assist in satisfying EU health and safety provisions. The 2013 Fisheries Regulations are designed to tighten controls of the entire fisheries sector and thus should go a long way in satisfying not only the EU's sustainability requirements but CITES requirements for non-detriment findings. The enacting of CITES regulations, however, lies outside the direct control of the Fisheries Division.

8.2.6 Objective 6: Maintain Compliance Rates With Respect to Size Limits above 85%

This ad hoc measure introduced in 2001 is seen as precautionary limit to ensure that most of the landed conch has been allowed to reproduce at least once before being removed from the system. In the absence of wholly accurate information on the status of queen conch stocks in Antigua and Barbuda it is necessary to continue this measure and far as possible ensure it is exceeded and improved over time.

To meet this objective the management strategy employed will be two-fold; (1) continued monitoring of queen conch landings through random biological sampling to determine the weight of landed individuals and (2) continued education and outreach to conch fishers to ensure their compliance with these provisions. Further, the co-management approach is expected to help in this regard by allowing for user buy-in to management controls. The key performance indicator for this condition remains compliance rates among fishers.

8.2.7 Objective 8: Adoption of Mechanisms for a Participatory Approach to Achieve Co-management

While the technical control measures provided for in the Fisheries Regulations are important tools for sustainable fisheries management, they will likely meet limited success in a system where users do not feel a sense of ownership for the resources they are utilising. Thus, coupled with these measures a co-management approach is being recommended as a viable and the most appropriate means of achieving sustainability in Antigua and Barbuda's queen conch fishery. Not only will this create the environment to foster user buy-in to resource management it also helps to ensure the concerns of resource users are considered during the decision making process. Fisheries management theory suggests that where resource users feel ownership of a resource they are more inclined to protect it. Thus, adoption of a co-management approach is likely to foster stewardship among conch fishers leading to better conservation of the species.

Additionally, co-management helps to overcome the limitations with regard to human and financial capacity experienced by the government agency responsible for managing the queen conch resources. The alternative management method of adopting catch quotas, though favoured, is costly and requires intensive research. Given the size of the fishery it is unlikely that government will commit to undertake the research necessary to determine annual catch limits and individual quotas.

The Fisheries Division already uses an ad hoc participatory approach for broad management of the fisheries sector. However, this approach is largely responsive to specific activities such as regulatory reforms or management plan reviews. Once these projects are complete there are no mechanisms in place to allow for continued participation of stakeholders in routine management of fisheries, despite there being several provisions in the Fisheries Act that provide for this.

In considering the co-management spectrum discussed in Chapter 5, it is useful to analyse the most appropriate system for achieving success in Antigua and Barbuda. Considering the failures that have been registered in other parts of the Caribbean and the similarities that exist between these states and Antigua and Barbuda it can be argued that it is unlikely that a co-management regime that devolves power to communities would find much success. Despite the small, homogenous nature of the queen conch fishery, Antigua and Barbuda, like many of these other countries, has yet to achieve success in organising strong fisherfolk organisations. Thus, a consultative/collaborative co-management regime is more likely to find success in this context and is recommended for the fishery.

Rolling out this regime requires that consideration be given; to who will participate in decision making, how debates are structured, knowledge used, conflicts solved and agreements reached. The review process discussed at length in Chapter 6 of this report helps to address most of these considerations. The participatory review and planning process represented in Figure 14 and employed by the Fisheries Division is a 7 tiered planning approach; from the time of plan formulation to implementation and review. The process includes a period of appraisal as well as several rounds of public review, which are iterative. The feedback mechanism entrenched in the planning process is one way to demonstrate to resource users that their concerns are not only being heard but are seriously considered and, where appropriate, adopted. The process has been successfully executed through a number of projects implemented by the Fisheries Division, including the review and update of the Fisheries Act and Regulations and the development of MPA Management Plans.

Considering the participants to the planning process, the Fisheries Division already has a general knowledge of the key stakeholders in this and other fisheries. The primary resource users should, of course, be the main participants to the planning process; however the Division also routinely engages other stakeholders including enforcement partners, non-governmental organisations, and community groups. Added to these, the Barbuda Council is a critical stakeholder, as that organisation is wholly responsible for managing the resources of that island.

Given the success that has been registered in executing the ad hoc planning process, it is recommended that this be formally recognised and adopted for the queen conch fishery, not only as a means of reviewing specific projects or plans but also as a means of allowing user participation in routine fisheries management. To achieve this, a number of prerequisites must also be fulfilled:

- Users should be organised in some formal way rather than enter the process as individuals.
- This necessitates that the group should find a means for consensus building so that the process recognises collective needs rather than individual requirements.
- This approach that is being presented should be agreed to by government as well as fishers.

If these prerequisites are not met from the outset the plan is unlikely to meet success.

A key component of meeting these requirements is the recommendation that queen conch fishers organise themselves into a legally recognised group or cooperative. This would help to give legitimacy to the co-management arrangement and assist in formalising the planning process. As a legal entity such a group would be required to prepare by-laws or procedures of operations, outlining membership requirements, voting procedures and conflict resolution, thereby meeting the second prerequisite. Finally, to formalise the arrangement, it may be necessary for government to enter into a formal MOU with this group whereby the responsibilities of each are clearly articulated, based on the "review planning process".

8.3 Possible Obstacles

Ultimately, the successful implementation of the queen conch management plan will depend on a number of external factors, over which the Fisheries Division has no direct control. There exist a number of possible pitfalls going forward, which if not acknowledged and prepared for, could ultimately result in failure.

Lack of political will among the government of day to see some of the stricter measures of the plan implemented (e.g. effort controls.)

The fisheries sector is largely seen as a safety net industry in Antigua and Barbuda. As the country struggles economically it is likely that fisheries will continue to be regarded as a viable economic activity, particularly among poorer sections of the community. The government may be inclined to put broader social issues above the need to conserve fisheries. The queen conch fishery, because of the inherent danger associated with the method of harvest, is unlikely to register exponential growth however as was demonstrated in 2008 the risk exists for unsustainable effort caused by external economic drivers.

Lack of interest and political will in seeing the co-management approach formalised.

The co-management approach currently operating in Antigua and Barbuda is largely ad hoc and responsive to particular projects or activities being undertaken by the Division. There is currently no method employed for allowing routine involvement of fishers and communities in the day-to-day management of fisheries. The plan calls for the formalisation of such a process for the conch fishery. The possibility exists that this may not be a favourable approach.

Lack of interest by fishers in participating in this new co-management arrangement
Antigua and Barbuda has a relatively poor history of organised cooperatives among fishers. The majority of fishers operating in Antigua and Barbuda remain unorganised, with the sole fisher cooperative having only about 250 members despite there being over 900 active fishers operating in Antigua and Barbuda. Despite this possibility, the queen conch fishery is more likely to register success than other fisheries sub-sectors because of its small size and the relatively homogenous nature of the operations.

Lack of human and financial resources to improve management of the fishery
One of the major findings of this assessment has been the large amount of uncertainty that exists regarding the status of queen conch stocks in Antigua and Barbuda. With an economy in recession and the government continuing to engage in various cost-cutting measures the possibility exists that the Fisheries Division will not be provided with the necessary human and financial resources to begin filling information gaps. This is particularly acute since the queen conch fishery remains relatively small and it is unlikely that government would allocate resources beyond the value of the fishery. Government may have to continue to look outside the national budget to external funding sources. This is not a sustainable approach to fisheries management.

Continuing degradation of key queen conch habitats
Like many island states Antigua and Barbuda's nearshore marine resources remains under threat of degradation from both anthropogenic and natural changes such as climate change. To ensure objectives regarding habitat protection are met it will be necessary for the country to fully implement management plans for declared protected areas.

Continued inability to meet export requirements under EU law and CITES
Because of the country's inability to meet the high demands placed on the government both by the country's major market, the EU, and the international convention, CITES, queen conch is largely a domestically marketed species. While government and fishers have an expressed interest in regaining external markets for queen conch the possibility exists that these demands may remain prohibitive without the necessary allocation of resources. Further, while the Fisheries Division has undertaken a significant amount of work to ensure it is able to undertake, with some degree of certainty, non-detriment findings under CITES, this could easily be eroded if the Standing Committee of that Convention recommends another trade suspension because the country has continuously failed to enact CITES enabling legislation. This particular issue lies outside the direct control of the Fisheries Division since the Environment Division acts as the CITES Management Authority and legislation for that department has been languishing incomplete for several years.

8.4 Next Steps

This document should be considered a framework document for the development of a management plan for Antigua and Barbuda's queen conch fishery. Final adoption and implementation of the plan will only be possible once it has undergone rigorous review and update with inputs from fisheries authorities, conch fishing communities and other relevant stakeholders in Antigua and Barbuda.

The framework document will first be presented to the national fisheries agency, the Fisheries Division before being taken to stakeholders for review. It is anticipated that, like other management planning processes undertaken in Antigua and Barbuda to date, this will be an iterative process subject to several rounds of review. Once the plan has undergone stakeholder review it will have to be presented to Ministry officials and the national government before it can become recognised as an official plan. This management planning review process has already been included in the Fishery Division's work programme for 2013.

9 CONCLUSION

Antigua and Barbuda's queen conch fishery, though small, has the potential to be an important contributor to the country's economy. This potential would be more readily realised if the fishery moves from a domestic fishery to one with foreign exchange earning potential through the regaining of external markets. Based on a bioeconomic assessment and information gathered from scientific research, there are indications that, despite its small size and apparent profitability, the fishery is operating at unsustainable levels. In fact it is largely believed that the fishery has been over-exploited in parts of the shelf, particularly the traditional fishing grounds of the Southwest. Based on data from 2010 the bioeconomic model suggests that current effort levels for the queen conch fishery are almost double what they should be for the fishery to operate at an optimal point.

It is recognised that the model parameters used have associated with them a great deal of uncertainty. To deal with this, a sensitivity analysis was conducted varying two of the parameters that were believed to have the greatest uncertainty associated with them; biomass growth and profitability of the fishery. This analysis yielded very similar results to the base assessment that was conducted. In all cases, the sensitivity tests showed that the fishery was operating over capacity, with effort levels too high. In all cases, the tests revealed that effort levels should be cut roughly in half to approximately 750 fishing days.

The overcapacity that is apparently being experienced in the queen conch fishery is even more acute following 2008 when the fishery registered almost a doubling in effort as a result of new vessels entering the fishery due to economic contractions in the lobster fishery. Prior to that time it appeared that the fishery was operating about optimal. This is of grave concern for the Fisheries Division, especially as it sets as one of the objectives for the fishery to regain market access to traditional markets lost as a result of changes in the export requirements under EU law. The newly enacted Fisheries Act and Regulations provide a regulatory regime that will allow for setting appropriate effort controls for the queen conch fishery. This, they do, through the provision requiring the issuance of special permits to vessels wishing to operate in the queen conch fishery and the condition that allows the CFO to set a limit on the number of permits that may be issued.

While output control measures such as the setting of TACs have been proven to find success in other queen conch fisheries in the region, Antigua and Barbuda is currently not at a stage where such a system can be successfully instituted. Setting reasonable TAC limits for a queen conch fishery requires relatively accurate scientific information regarding the status of such stocks. The research required to garner this information may be lengthy, costly and in need of significant human capital to effectively execute it. It is unlikely that the financial resources to conduct such rigorous and routine assessments for the queen conch fishery in Antigua and Barbuda will be forthcoming from a government system currently in a recession. It is also unlikely that government will allocate research funding that exceeds the value of the fishery, as will likely be necessary to capture the kinds of information required to accurately estimate stock abundance. This will have to remain a long-term goal. In the interim, however, a co-management approach is recommended as a viable means of achieving sustainability in the queen conch fishery. The fisheries management literature widely suggests that such an approach is likely to find success, as fishers are more inclined to work towards sustainability once they perceive to have ownership of a resource and contribution to its management

The queen conch fishery in Antigua and Barbuda is small, homogenous and largely based in two communities in Antigua and Barbuda, and therefore is an ideal candidate for establishing a co-management regime. An ad hoc co-management process already exists in the fisheries sector, though this has largely been issue based rather than a proactive measure for fisheries management. Despite this, the ad hoc process employed has found much success, as evidenced through the important strides made in tightening fisheries controls with the update of the Fisheries Act and Regulations and the key role played by fishers and other stakeholders in seeing this to completion. This gives hope that the Fisheries Division will also find success in formalising the process to allow for a co-management system that gives resource users the opportunity to participate in routine management of a fishery. Hopefully, by adopting such an approach in the queen conch fishery, the Fisheries Division will set the scene to see this regime applied to other fisheries with similar characteristics.

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APPENDIX

Appendix 1: Declaration of Panama City

CFMC/OSPESCA/WECAFC/CRFM[1]Working Group on Queen Conch (QCWG)

Panama City, Panama, 23–25 October 2012

Declaration of Panama City

The Members of the CFMC/OSPESCA/WECAFC/CRFM Working Group on Queen Conch:

Recalling the Terms of Reference of the joint Working Group, as established by the 14th session of the Western Central Atlantic Fishery Commission (Panama City, 6-9 February 2012);

Noting with concern the on-going challenges in ensuring sustained and legal utilization of queen conch (*Strombus gigas*) resources, complying with CITES Appendix-II provisions for international trade in the species, and the limited progress made in terms of regional collaboration and coordination of the management of the resource;

Mindful of the socio-economic importance of the queen conch fisheries for the Wider Caribbean Region;

Reiterating the declaration of San Juan, made by the First International queen conch Conference, held in San Juan, Puerto Rico, in 1996, where several Caribbean countries agreed to cooperate in the management of the queen conch for the benefit of all nations involved, and the recommendations of the International queen conch Initiative - CITES workshop, held in Montego Bay in 2003 that were communicated in CITES Notification to the Parties No 2006/055 and that all range States of queen conch are invited to implement;

Recognizing that in recent years, national efforts for the management and conservation of queen conch have increased in the region, leading to encouraging developments such as better stock protection, improved understanding of the species ecology and management needs, and enhanced enforcement to combat illegal catch and trade, and that most of this progress made was CITES driven;

Further recognizing the efforts at local, national and regional level to manage queen conch fisheries in line with the FAO Code of Conduct for Responsible Fisheries, the 1995 UN Fish Stocks Agreement, the precautionary approach and the Ecosystem Approach to Fisheries (EAF) as regionally promoted by the Working Group members, the 2009 FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, and the provisions of CITES for international trade in the species; 2

Mindful of the obligations and available opportunities to the countries that are Party to the SPAW Protocol to work collaboratively to implement plans for conservation of queen conch, which is listed in Annex III of that Treaty;

Convinced that scientific research on the biology, life cycle, conservation and management of queen conch should continue to inform fisheries decision makers on *inter alia* suitable harvest and fishery

[1] This is a joint species specific Working Group of the Caribbean Fisheries Management Council (CFMC), Organization for the Fisheries and Aquaculture Sector of the Central American Isthmus (OSPESCA), Western Central Atlantic Fishery Commission (WECAFC) and the Caribbean Regional Fisheries Mechanism (CRFM)

strategies, precautionary controls, appropriate fishing capacity, and measures to enhance enforcement and compliance;

Appreciating the agreement on a Joint Action Plan of CRFM and OSPESCA, concluded in September 2012, which emphasizes the need for joint work *inter alia* on queen conch research and sustainable management, and the on-going work by CFMC, CITES and WECAFC towards sustainable utilization of the resource;
Committed to individually and collectively taking measures and actions to further improve the management and conservation of the queen conch resource in the Wider Caribbean Region;

1. RECOMMEND the immediate implementation, as applicable, of the recommendations made by the Queen Conch Expert Workshop, held in Miami, USA, 22-24 May 2012, and reviewed and validated by the Working Group during the meeting in Panama City on 23-25 October 2012, taking into account recommendations made by the Working Group on paragraphs 1 and 5 (see Annex);

2. RECOMMEND that WECAFC, OSPESCA, CRFM and CFMC support the development of a regional plan for the management and conservation of queen conch, in accordance with the best available scientific evidence to be presented to the 15th session of WECAFC for review, consideration and regional adoption;

3. RECOMMEND that the Conference of the Parties to CITES take account of and discuss the information and “draft decision” provided by Colombia at its 16th meeting, and adopt recommendations as appropriate to support the sustainable utilization, conservation and international trade in queen conch;

4. RECOMMEND that OSPESCA and CRFM support the development and adoption of sub-regional regulations for queen conch, and support the implementation of these regulations by their member States;

5. RECOMMEND that the fisheries authorities in the region increase awareness and build capacity among fishers on Safety-at-Sea and in particular address risk management in and alternatives to compressed air diving for queen conch and seek assistance where necessary;

6. RECOMMEND the queen conch range States, CITES and FAO to cooperate closely and work jointly on the improvement and standardization of trade data and statistics (through regionally agreed conversion factors) for queen conch and its derivatives such as pearls, shells and opercula;

7. RECOMMEND that fisheries authorities with support of CRFM, OSPESCA, CFMC and WECAFC strengthen the participation of fishers in the decision making related to implementation of measures for management and sustainable utilization of queen conch.

REQUEST THE RESPECTIVE SECRETARIATS to present this declaration for endorsement to the 15th Session of WECAFC, which is scheduled to be held in Trinidad and Tobago in 2014, as well as to the next session of the Caribbean Fisheries Forum of CRFM and the next ministerial meeting of OSPESCA and communicate it to the CITES Secretariat for further dissemination; and

SOLICIT the support for, and the direct and immediate implementation by the countries in the Wider Caribbean Region of the above listed recommendations.

Appendix 2: Estimates of running costs for the queen conch fishery – Inflation adjusted

Open Vessel				
	2001		***2010***	
	Cost per vessel 120 Fishing days	Cost/vessel /fishing day	Cost/vessel/day	Adjusted total cost/vessel/ day (64 fishing days)
Fuel	7,482.34	62.35	107.62	6,887.75
Lubricant	1,233.47	10.28	13.14	841.26
Food	1,127.51	9.40	11.89	761.12
Labour	5,795.15	48.29	73.68	4,715.24
General Expenses	24.45	0.20	0.26	16.68
Dive Tanks	N/A	NA	326.03	20,865.79
Sub Total	15,662.92	130.52	532.62	34,087.84
Fibreglass Launch				
	2001		2010	
	Cost per vessel 104 Fishing days	Cost/vessel /fishing day	Cost/vessel/day	Adjusted total cost/vessel/ day (64 fishing days)
Fuel	27,313.00	262.62	453.29	29,010.60
Lubricant	1,016.12	9.77	12.49	799.64
Food	3,893.32	37.44	47.38	3,032.48
Labour	7,849.12	75.47	115.14	7,369.00
General Expenses	24.45	0.24	0.30	19.24
Dive Tanks	Not available	Not available	543.38	34,776.32
Sub-Total	40,096.01	385.54	1,171.99	75,007.28

Appendix 3: Result tables of the fisheries bioeconomic model for both high end and low end estimates of virgin biomass and MSY

Main Results	High End Estimate – Virgin biomass = 10, 000 MT and MSY = 306 MT						
		Current		Optimal		Difference	
	Units	Logistic	Fox	Logistic	Fox	Logistic	Fox
Biomass	MT	917.5	372.8	5236.3	3876.6	4318.8	3503.8
Harvest	MT	102.0	102.0	305.3	305.6	203.3	203.6
Effort	Day-trips	1207.00	1207.00	753.50	439.48	-453.50	-767.52
Landings Price	XCD/MT	20.94	20.94	20.94	20.94	0.00	0.00
Revenues	1000 XCD	2135.9	2135.9	6393.3	6398.5	4257.4	4262.7
Costs	1000 XCD	1363.9	1363.9	981.8	717.3	-382.1	-646.7
Profits	1000 XCD	772.0	772.0	5411.5	5681.3	4639.5	4909.3
Profits per unit revenue	Ratio (percent)	0.361	0.361	0.846	0.888	0.485	0.526
Profits per unit effort	1000 XCD/Day-trips	0.640	0.640	7.182	12.927	6.542	12.288
Profits per unit harvest	1000 XCD/MT	7.568	7.568	17.724	18.593	10.156	11.025
Rents	1000 XCD	1118.9	1118.9	5758.5	6028.3	4639.5	4909.3

Main Results	Low End Estimate – Virgin biomass = 1, 000 MT and MSY = 214 MT						
		Current		Optimal		Difference	
	Units	Logistic	Fox	Logistic	Fox	Logistic	Fox
Biomass	MT	138.3	63.7	534.4	399.6	396.1	336.0
Harvest	MT	102.0	102.0	213.0	213.2	111.0	111.2
Effort	Day-trips	1207.00	1207.00	746.56	483.03	-460.44	-723.97
Landings Price	XCD/MT	20.94	20.94	20.94	20.94	0.00	0.00
Revenues	1000 XCD	2135.9	2135.9	4459.9	4464.9	2324.1	2329.0
Costs	1000 XCD	1363.9	1363.9	976.0	754.0	-387.9	-610.0
Profits	1000 XCD	772.0	772.0	3484.0	3711.0	2712.0	2939.0
Profits per unit revenue	Ratio (percent)	0.361	0.361	0.781	0.831	0.420	0.470
Profits per unit effort	1000 XCD/Day-trips	0.640	0.640	4.667	7.683	4.027	7.043
Profits per unit harvest	1000 XCD/MT	7.568	7.568	16.358	17.404	8.789	9.836
Rents	1000 XCD	1118.9	1118.9	3830.9	4058.0	2712.0	2939.0