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REGIONAL REVIEW OF THE QUEEN CONCH FISHERIES

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Belize 2013

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Prepared by:

MRAG, under contract to the ACP Fish II Project, on behalf of the Caribbean Regional Fisheries Mechanism (CRFM) Secretariat

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FOREWORD

In 2013, the EU-sponsored ACP Fish II Programme commissioned a study titled 'Support to improve and harmonize scientific approaches required to inform sustainable management of queen conch (*Strombus gigas*) by CARIFORUM States'. The study was executed by MRAG on behalf of the CRFM Secretariat, and upon completion, a Final Technical Report was submitted to the ACP Fish II Programme that contained 4 major outputs of direct interest to the CRFM: a regional review of scientific and management approaches to the management of queen conch; 5 country mission reports or case studies that were used to inform the regional review; a regional management options paper that was developed based on the regional review and country cases studies, and; the report of a workshop held to validate the other 3 major outputs.

To make the 4 major outputs more readily identifiable as CRFM-approved, and also more easily available to the various CRFM publics, they have been extracted from the original Final Technical Report submitted to the ACP Fish II Programme, and reproduced as CRFM Technical and Advisory Documents 2013/11 (regional review and cases studies), 2013/12 (workshop report) and 2013/13 (regional management options).

The CRFM Secretariat acknowledges the contribution of the EU-sponsored ACP Fish II Programme in this endeavour.

LIST OF ACRONYMS

ACP	African Caribbean Pacific
BFD	Belize Fishery Department
CARICOM	Caribbean Community
CARIFORUM	Caribbean Forum of ACP Countries
CARIFIS	Caribbean Fisheries Information System
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources
CDS	Catch Documentation System
CERMES	Centre for Resource Management and Environmental Studies
CFMC	Caribbean Fisheries Management Council (US Caribbean)
CITES	Convention on the International Trade in Endangered Species
CODOPESCA	Consejo Dominicano de Pesca y Acuacultura
CPUE	Catch Per Unit Effort
CRFM	Caribbean Regional Fisheries Mechanism
CRFAMP	CARICOM Fisheries Resource Assessment and Management Programme
DMR	Department of Marine Resources
DOF	Department of Fisheries
DR	Dominican Republic
EAF	Ecosystem Approach to Fisheries
EU	European Union
FAB	Fisheries Advisory Board
FAO	Food and Agriculture Organization of the United Nations
FMP	Fisheries Management Plan
GIS	Geographical Information System
GPS	Global Positioning System
HACCP	Hazard Analysis and Critical Control Points
IUU Fishing	Illegal, Unreported and Unregulated Fishing
ICCAT	International Commission for the Conservation of Atlantic Tunas
LRS	Licensing and Registration System
MCS	Monitoring Control and Surveillance
MOU	Memorandum of Understanding
MPA	Marine Protected Areas
MEY	Maximum Economic Yield
MYS	Maximum Sustainable Yield
NGO	Non-Government Organizations
NPOA	National Plan of Action
OECS	Organization of Eastern Caribbean States
OSPESCA	Central American Organization for Fisheries and Aquaculture Sector
PNE	East National Park
PNJ	Jaragua National Park
QCEW	Queen Conch Expert Workshop
RFMO	Regional Fisheries Management Organization
SPAW	Specially Protected Areas and Wildlife
SQL	Structured Query Language
TCI	Turks and Caicos Islands
UNCLOS	United Nations Convention of the Law of the Sea
VMS	Vessel Monitoring Systems
WCS	Wildlife Conservation Society

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Executive Summary

1. This report provides an overview of the status of queen conch fisheries and queen conch fishery management performance in the ACP Caribbean region, providing information to improve queen conch fishery science, and to develop options for incorporating scientific information into effective management strategies.
2. Total catch and catch and effort data have been most successfully provided from processors and exporters, usually from purchase receipts. This method has not, in general, been extended to small scale businesses, but has been successfully implemented for larger processors/exporters and in central markets.
3. Some countries, but not all, collect catch and effort data from trip interviews routinely. Where these exist, they provide good quality data not only for conch, but for all fisheries. However, there has been no further development of this approach in the region.
4. An important constraint on data collection systems is whether they have been computerized, particularly so that data can be provided to fisheries departments in computerized format.
5. Belize and Jamaica depend on abundance information from visual surveys to assess their conch stocks. These have become a standard well developed method to collect information on biomass, density and stock structure.
6. There is no catch documentation system (CDS) in the region for conch, although such a system could be useful for monitoring legitimate catches. Catches being exported to Europe require an authorized catch certificate.
7. Some countries have not published national or regional standard conversions between different processing levels. In some cases, national statistics exist and are used internally.
8. Recent analyses vary from assessments based on single abundance surveys to biomass dynamics modeling based on catch and effort data. Some attempts in the past have been made to use size composition data in age structured models, but the data for most countries are not adequate and difficult to interpret in this regard. A number of countries do not have adequate data to carry out standard stock assessments.
9. There are a number of opportunities for regional support and harmonization in:
    a. supporting appropriate fishery data collection systems through mandatory reporting within trade;
    b. harmonizing conversion factors in the region to ensure consistent measurement of catch;
    c. developing a regional CDS to combat IUU and to support management of the legal fishery for conch;
    d. developing appropriate scientific techniques to provide robust advice for low data fisheries; and,
    e. providing an independent review system that improves advice and guidance as well as increasing the credibility for harvest strategies.

Introduction

The purpose of this review is to provide an overview of the status of queen conch and queen conch fishery management performance in the ACP Caribbean region. This information will be used to improve queen conch fishery science, and to develop options for incorporating scientific information into effective management strategies.

For most fisheries the stock status is unknown or at least highly uncertain. This is the root of concern for these fisheries, and the main reason the fisheries are constantly under threat of international sanction. To deal with this, the fisheries management must take action at national and regional levels.

The general approach for managing queen conch fisheries consists of a harvest strategy, which is a collection of management controls that limit the exploitation to sustainable levels, and a feedback-control system that allows the fishery to respond should the stock be unexpectedly depleted (Medley, 2008).

Decisions on exploitation limits and controls depend upon the quality of the information used to assess the stock status, the frequency that information on status can be obtained and the level of precaution that needs to be applied. Generally, the worse the information, the greater the precaution needed in setting exploitation levels. It is therefore valuable to set up efficient and effective monitoring systems that are able to report stock status with as great a precision as possible.

A Queen Conch Expert Workshop (QCEW 2012) made a number of recommendations in 2012 to provide guidance on what might be expected in a well-managed queen conch fishery. These recommendations were adopted, with a few comments emphasizing some flexibility required in implementation, at the WECAFC meeting in Panama (FAO 2013) and linked to a resolution for the Convention on International Trade in Endangered Species (CITES) Conference of the Parties meeting in 2013 (CITES CoP16 Com. I. 5.). This report intends to make a contribution to this process by helping to define best practice in queen conch fishery management, which might be used to define a standard required to engage in the international trade in queen conch. In this regard, it should be noted that case studies were conducted for 5 CARIFORUM countries to provide a deeper understanding of the challenges and opportunities in practice and in so doing, to help inform recommendations on the way forward. The complete country case study reports are given in *Annexes 1 to 5*.

Background

Key Attributes of Conch Biology

All harvest strategies have the same basic requirement. Catches should be limited to a level such that the stock can replenish itself and does not become depleted. However, some stocks have attributes in their biology that make them more susceptible to overfishing or more difficult to monitor. Harvest strategies should take account of these attributes.

In the case of conch, there are four attributes which make the stocks more vulnerable:

1. Conch are easy to catch. Conch cannot be harvested using industrial gears such as trawl, but require divers to collect them. However, being found in shallow water (<50m), they are easy to find, capture and process. Without compressed air, it is difficult to capture conch from below 10m depth. With compressed air, conch can still be caught safely to depths of 30m, although with a reduced bottom time their catchability is reduced in deeper water.
2. Conch cannot be aged. Ageing is important in many scientific monitoring schemes, and currently the age can only be inferred by the conch size. However, conch growth appears complicated and

variable (Ehrhardt and Valle-Esquivel 2008). In addition, conch are often not landed with those parts considered most accurate for estimating age (shell or possibly the operculum).

3. Conch appear to have a highly variable mortality throughout their life (Appeldoorn 1998b). Mortality of larvae, post-larvae conch and juveniles appears high. However, in unexploited populations what appear to be very old ("stoned") conch are present, implying that natural mortality is significantly reduced in older mature conch. This can lead to a very high abundance or standing stock, which may lead to an initial overestimate of the stock productivity. Furthermore, the stability of such populations may depend upon the longevity of mature conch, which, being susceptible to fishing, can be depleted rapidly, leading to long-term recruitment failure.
4. Conch may exhibit a reduction in spawning potential if densities are reduced too low. Surveys have clearly detected a significant decrease in spawning activity in conch when conch density falls to low levels (Stoner *et al.* 2012). The cause is not known, but could simply be due to difficulties conch may have in finding mates at these densities.

Given there are examples where stocks appear to be very slow to recover, such as in Florida, there is considerable concern that while this species may be resilient to high fishing mortality, once depleted may not recover easily. This makes these fisheries vulnerable to serial depletion and the demise of conch fisheries across the region. To ensure that this does not happen, good monitoring and control systems are required even in the smaller fisheries.

Types of Fishery

The largest fishing operations in terms of total catch consist of a single mothership with a set of smaller catcher boats. The catch is processed at sea and conch are landed already cleaned and frozen and in some cases may not be landed in the vessel's flag state. The main implications of this are that there is no opportunity to monitor uncleaned conch meat unless observers are placed aboard the mothership. The Jamaican Pedro Bank fishery is the only fishery likely to predominantly be considered industrial among the CARIFORUM states. However, this type of operation is also found to a lesser extent in The Bahamas, Dominican Republic and Belize among fleets consisting predominantly of smaller artisanal vessels.

The most widespread type of fishery in the Caribbean are smaller artisanal vessels which operate from landing sites on one day trips. Vessels usually have a crew of 2-3 on each boat. Vessels are now mostly made of fibre-glass and are relatively fast boats with petrol outboard engines. These vessels may not only target conch, but may catch conch opportunistically alongside lobster and finfish, and otherwise may target conch particularly during a lobster closed season. Predominantly, the meat is landed uncleaned, but without the shell which is discarded at sea.

Many conch fisheries in the region are very small scale. Most Caribbean islands have a purely subsistence fishery for conch as well as fisheries which catch conch opportunistically or target conch periodically. These fisheries may land conch at a wide numbers of sites in small quantities. Depending on their location, there may also be some exports to neighbouring islands. For example, Grenada exports conch to other islands (mainly Trinidad and Tobago, and Barbados), but a substantial proportion is consumed locally.

Conch Fisheries Management

Policy and Legislation

A clear fishery policy with objectives is necessary for providing relevant scientific advice. Government conch fishery policy is guided by CITES requirements in all countries. Perhaps the most important role of policy is to define objectives and constraints for each fishery, and give some guidance on acceptable levels of risk. Policies should also recognise conflicting objectives, but often these are not clearly

identified. There have been recent initiatives in developing a common fisheries policy (CRFM, 2011) and tackling illegal fishing in the region (Castries Declaration, 2010), which, while not specific to conch, points to initiatives which would benefit queen conch fishery management. These include specific initiatives to implement standard FAO vessel marking and develop a comprehensive database of fishing vessels in good standing.
A first objective may be to determine the status of the fishery and ensure exploitation is at sustainable levels. Other policies might include the protection of critical habitats for conch from exploitation and degradation. For most fisheries, a consultation with stakeholders has been used to develop other reasonable goals for the fishery, but often these remain vague. Fisheries management policy may also indicate its intention to apply an ecosystem approach, in which conch and fishers are components of the system.

A particularly desirable objective in all fisheries is to maintain current fisher earnings, which is a difficult policy to implement as any reduction in catches to protect the stock implies a reduction in fisher income. Any control that conserves the stock must limit or reduce catches to be effective.

Employment tends to be an important consideration in artisanal fisheries, and therefore most countries are more orientated to maintaining and extending livelihood opportunities. New opportunities in the fishing industry are more likely to be in improving quality and the value added to fish products rather than increasing the quantity landed.

In CARIFORUM countries, fisheries legislation makes provision for fishing licensing and registration (local and foreign); fisheries research; fish processing and export licensing; the establishment of a broad array of conservation measures and regulations, such as minimum sizes, closed seasons, gear restrictions and marine reserves; and the enforcement of regulations and conservation measures. In some cases, legislation is being updated, but most legislation makes adequate provision for good management practice if resources are available to implement it.

Most fishery policy does not discourage fishery development, but assumes fishing is another part of the developing economy. Most conch fisheries should be considered fully developed and new entrants in the processing or fishing industry should be discouraged. This may be in contrast to other parts of the economy, which may still be developing.

While direct subsidies to the fishing industry do not exist, indirect subsidies such as tax-free imports of gear are common. Any subsidies that promote fishing activity should be discouraged or linked to sustainable fishing practices.

Most fisheries do not have a fisheries management plan (FMP), although a few have FMPs in draft form and at best have been partially implemented. An important step in fisheries management is to develop a FMP which is realistic and can be fully implemented. In some cases, FMPs are perhaps too ambitious and present a series of activities that a fisheries department would like to carry out, but may have neither the resources nor capacity to implement.

Controls and Interventions

The conch fisheries of member countries are generally considered to be in good condition given the various management measures currently being implemented in each country (Table 1). In the case of Jamaica, the conch fishery has seen a substantial reduction in catch and fishing effort and the legal fishing mortality rate has declined from 0.22 $year^{-1}$ in 1994 to 0.04 $year^{-1}$ in 2011. However, a number of countries have encountered conditions which may be placing their fisheries at increased risk. Catches in Belize and The Bahamas have recently increased compared to historic levels, and catch rates in the Turks and Caicos Islands have been relatively low (most likely due to high recruit mortality from hurricanes).

For these countries, it is necessary to assess whether current controls are sufficient or additional interventions will be required.

In many cases, controls have not been evaluated in terms of whether they are achieving objectives, mainly because there is inadequate information to carry out such an evaluation.

Most conch fisheries require vessels and fishers to possess a licence, at least for larger vessels. Controls on commercial fisheries can be applied as conditions of a fishing licence. However, controls on all fishing, including recreational and subsistence, which is a significant part of conch fisheries, require considerable outreach and educational activities to get compliance. Significant investment in education and outreach on regulations, such as minimum size, may discourage significant change.

A number of small scale fisheries have no clear harvest strategy in place, but do implement precautionary controls. Most CARIFORM countries have a minimum size regulation and many implement a closed season. For example, the St. Kitts and Nevis conch fishery does not have a closed season, but conch is caught for local consumption only.

Introducing effective limits or reductions on fishing mortality may be made easier when combined with other management initiatives aimed at improving working conditions for fishers. Fishing, particularly when using compressed air, should be seen as a profession with opportunities to educate on various issues such as safety at sea, how to avoid decompression sickness, improving catch quality, running a small business and so on. This might be best achieved through non-government fisher organisations.

The QCEW (2012) recommended some precautionary controls which might be applied where information was insufficient to show the stock was in good condition. Such "precautionary" limits on fishing are invariably unpopular with fishing communities, and may have a significant negative impact on socio-economics and employment. It is likely that any management actions aiming to reduce fishing will be strongly resisted by the fishing industry.

There are a number of controls which, if harmonised across the region, would become easier to enforce. These might include a closed period around main spawning times, and a minimum meat weight that can be enforced within the international trade.

Table 1. Management controls applied among CARIFORUM states

Type	**Comments**
Effort limits	Jamaica applies catch and effort controls. The conch fishery is large enough to require a fishing permit specific to conch, which allows a direct control on fishing effort and landings. For other fisheries in the region, there is a reliance on *de facto* fishing effort limits, which are the result of the limited availability of skilled fishers within the national population. For all countries concerned, commercial fishing cannot be carried out without a commercial fishing licence, and commercial fishing licences may only be issued to nationals. However, any national who applies for a licence is likely to be issued with one, so the level of fishing may depend upon other economic opportunities available. Most countries have a vessel register, but this is not necessarily under the department of fisheries control. For example, the Bahamas vessel register is held by the Maritime Authority and covers all vessels. Vessels less than or equal to 20 feet (6.1m) length do not have to get a commercial licence from the fisheries department to fish. Direct control over fishing effort is not possible unless there is, at the very least, an active licencing system for all fishing vessels.
Vessel Monitoring Systems	Although recommended for larger vessels to combat IUU fishing, satellite based vessel monitoring systems are not being used in these fisheries with the exception of Jamaica. There is concern over costs of implementation and appropriate systems

	for smaller vessels are being investigated. VMS has been identified as having an important role in regional management and tackling IUU fishing (Castries Declaration 2010; CRFM 2011)
Minimum Size	Most countries have a minimum size, which in most cases is applied to the shell. In many countries, however, there appears to be little or no enforcement of the regulation. Shell size limits where the shell is not landed are very difficult to enforce. Evaluation of size limits in the Belize fishery, which predominantly targets sub-adults, has been evaluated and was found effective (Appeldoorn pers. comm.). The Bahamas size limits (only allowed to land conch with a flared lip) are suspected as being below the point of maturity, and it has been suggested that the minimum size might be raised in this case (Stoner *et al* 2012b), although the effect on the population and fishery has not been evaluated. Elsewhere, size limits have not been evaluated.
Export quota	Countries, such as Jamaica, Turks and Caicos Islands and Belize, with larger fisheries which export conch, have export quotas which are enforced at point of export and import to the USA.
Closed Season	Closed seasons are widely, but not universally, used by CARIFORUM states. In many countries such as the Bahamas and Turks and Caicos Islands (TCI), fishers switch to conch during the lobster closed season. For the TCI, a conch closed season was introduced at the start of the lobster season primarily to ensure that the conch export quota would continue through the lobster closed season.
Closed areas	The distributed nature of a fishery makes closed areas or marine reserves a useful tool to reduce risks of overfishing, but implementation and, in particular, enforcement may be difficult unless the fishers themselves support the initiative. Closed areas are generally considered a success in Belize, with higher abundance in those areas implying significant biomass is protected (Appeldoorn 2004). Closed areas in Belize cover important habitat areas and provide a conduit for juveniles to move through fishing areas to deeper water. In contrast, closed areas appear to be failing to provide significant protection in the Bahamas, with surveys reporting declines in abundance within marine protected areas which have been surveyed more than once (Stoner *et al*. 2012a). This is most likely because the proportion of the stock covered by MPAs is too small to be effective.
Gear controls	Prohibiting the use of compressed air prevents fishers exploiting populations in deeper water, so the spawning stock will have lower mortality. This is used effectively in Belize and the Turks and Caicos Islands. However, it is not possible to apply to all fisheries since the population may not be accessible in shallow water. For example, Jamaica's Pedro Bank fishery needs to exploit areas below 10m depth to be viable. The only other possible controls might be on the size of engine or vessel, but this would affect other fisheries and has not been implemented in the region.

Case Study: Belize Harvest Strategy

Belize's conch fishery is characterized as a shallow water artisanal small-scale fishery that primarily targets legal-sized pre-adult individuals in the fishing grounds. The production has been stable over recent decades.

The stock size is evaluated through visual surveys that estimate the biomass, density and stock structure. This is used to set limits on exports and overall fishing effort. Surveys over the last 10 years indicate that the stock has been stable or increasing. It is also believed that there are adult spawners in deeper waters (domed-shaped selectivity,) which are relatively unexploited and help protect the spawning stock.

As well as catch limits, Belize has closed areas, and a minimum size. A significantly high proportion of the fishable biomass can be found in the reserves and marine protected areas, which has been evaluated and found effective. A minimum size limit placed on meat weight has also been shown to be effective.

Fishing effort (number of fishermen) shows an increasing pattern and is mainly responsible for the recent increase in landings. This suggests that current controls on fishing effort are not fully effective. The control of fishing effort is being tested through the implementation of a managed access program in two marine reserves used as pilot sites. The program has produced very good results as fishermen participate in the decision-making process and are complying with data reporting. There have been increased patrols and compliance with regulations, reduced illegal fishing and greater cooperation with the authorities.

Conch production has shown an increase since 1989, with a major leap of more than 150,000 pounds in 2011, due to increasing fishing effort measured as the number of fishermen (CRFM 2012a). This suggests that some additional control or limit on fishing effort may be required to avoid more painful restrictions in future. Belize is having some success with managed access to areas, which should give more precise control over fishing effort.

Enforcement and Compliance

Each export consignment will require a CITES permit from the management authority. The CITES permit should always be approved by the fisheries department whether the fisheries department is the designated scientific authority or not. All products should be inspected before export. Inspection covers health as well as conservation requirements.

Jamaica has been successful in reducing the total catch to close to 1000 t (Aiken *et al*., 2006) which has led to a reduction of effort and the relatively good status of the stock. This catch limit is applied through an export quota. Similarly, the other main exporters, the Turks and Caicos Islands and Belize have applied effective limits on fishing mortality through an export quota.

An important concern for Jamaica and other countries has been illegal, unreported and unregulated (IUU) fishing. While direct enforcement, through patrol vessels for example, has not been undertaken because of the expense, control through trade (i.e. CITES) has been used to apply pressure to reduce illegal fishing. However, there have been some recent regional initiatives to deal with illegal, unreported and unregulated (IUU) fishing (CRFM MCS study[1]; Castries Declaration, 2010; an ACP Fish II Programme activity updating the 2005 MCS study), although provisions from these have yet to be implemented. Further projects under ACP Fish II on monitoring control and surveillance are planned.

The QCEW (2012) made a number of suggestions, but concrete proposals are required to address this issue. An important component of enforcement against IUU is to negotiate the requirement that all fishing vessels are clearly marked so that they can be identified from the air as well as from sea. This is required and generally enforced by all CARIFORUM states. Other effective controls on IUU include requiring vessels which may be involved in illegal activity to have VMS, sharing monitoring information among states on vessel activity, catch documentation systems and ensuring fishing capacity is commensurate with the resource productivity. Generally, enforcement at sea is difficult and expensive and success across the region for enforcement at sea has been low.

Ecosystem Approach to Management

The ecosystem approach to management aims to consider wider implications of fishing on habitat, species and other components of the ecosystem. It also requires fishing activities be considered as part of the ecosystem, implying co-management and specifically consultation with stakeholders.

[1] Caribbean Regional Fisheries Mechanism (CRFM), 2005 (a). *A review of the current situation on IUU fishing and MCS in the fisheries sector of the CARICOM/CARIFORUM region. Strategy for enhancing the effectiveness of MCS and a proposal for a project to enhance the effectiveness of MCS*. 52 p.

The focus of the ecosystem approach is most often on implementing the management controls, predominantly MPAs or no take zones. However, full and effective ecosystem management will require building a better understanding of the ecosystems and habitats on which conch fisheries depend. This would be a long term plan to build a better understanding of the ecology, maps of habitat and ecosystem components, and investigate the links between them.

Decision Making

Ultimate authority always rests with the Minister for Fisheries, although decisions should be made based on scientific advice and agreed with stakeholders. Arbitrary unjustified decisions will lose international confidence in the sustainability of the fishery.

Fishers should have a significant role in management decisions, which will encourage industry to abide by them. Participation is generally good in the Caribbean, but their role in the decision-making process is not always clear. Depending on their size, many fisheries are involved in decision making through representation rather than participation. Strong fisher non-government organisations are therefore important for developing co-management.

It is increasingly recognised that well-defined harvest control rules have an important role in effective fishery management systems, but have not yet been applied in conch fisheries. These may codify current practice or improve current practice, but in all cases they should make management decisions more transparent and improve international confidence in the system. Harvest control rules also serve as a way to communicate how decisions might be made among stakeholders and are able to deal directly with uncertainty.

Uncertainty has an important role in fisheries decision-making. Risk can be dealt with through management decision-making (applying the precautionary approach) or through research. Research that has a large impact on decisions should be given high priority. More strategic research should still be carried out, but probably have lower priority.

Feedback and Review System

A critical question within the international context is whether there is a credible, effective fisheries management system in place in each country. In building credibility, management systems are best reviewed by independent, external experts who have no conflict of interest. This cannot be done by the same people who are running the system or who have some investment in it (stakeholders). Many of the benefits from such reviews do not necessarily come from the review itself, but arise from the transparency, making information public and discussing issues and problems in an open way. Each review of one fishery will benefit all fisheries in the region by sharing experience of best practice and providing a clear standard to which management systems can aspire.

All countries have a national CITES committee which is responsible for reviewing CITES issues, of which conch is one concern. The committee, made up of independent scientists and people from institutions interested in conservation, should review both the science and decision-making. However, as is the case for CITES itself, these committees do not necessarily have members who are familiar with fisheries science and may not be familiar with fisheries issues. The committees depend upon guidance given them by the fisheries departments.

It is necessary to have systems which can review the data, science and scientific advice to ensure that it is the best available. This could be achieved by establishing new working groups or using current working groups to review scientific advice regarding queen conch fishery policies and practices, and regularly evaluate the management performance of States involved in queen conch fishery and trade. CRFM

already has a conch and lobster working group which could provide a useful external reviewing role at no additional cost. Otherwise, review groups could be set up within countries, but these would less likely be seen as independent.

Finance

Financial resources to carry out necessary management tasks should be raised from the fishing industry, at least in the long term. External funding could be obtained for short term tasks, but relying on external funding is not sustainable.

An export tax provides a useful way for targeted funding and also provides some bioeconomic protection for the stock, since it effectively lowers the price obtained for the product. Integrating fishery surveys with other types of survey may provide another opportunity to reduce costs on remote banks.

Money from fisheries taxes and licence fees need not be ring fenced for fishery management purposes. Government should meet management costs from general taxation, but any costs for fisheries management purposes should be less than the overall benefits which accrue from fishing, including taxes, fees, and services (such as food security and social employment). If there is a perception that fishery management is being subsidised, it will not be sustained.

Therefore costs of management, including data collection and scientific research, must be commensurate with the size of the fishery, industry profit and fisher earnings. For many of these fisheries, it will be a challenge to develop management systems which both meets best practice and have appropriate costs.

Catch Data

Data Collection

The total catch provides a quantitative measure of the impact of the fishery on the population. It is probably the single most important piece of information that a fishery should always report. Conch presents some problems commonly found in small scale fisheries, which make it difficult to record all landings. There are different approaches to the problem around the region.

Wherever possible, catches should be reported by processors and exporters. This approach is successfully used by countries relying predominantly on exports. This information should ideally be submitted in computerized form. It is likely that processors will maintain records on their product in computerized form anyway, so requesting data in this form should not be onerous. To ensure consistency, government should provide the data forms that need to be completed, which should make measurement units clear, and provide as much basic data entry checks as possible to minimise mistakes.

A purchase receipt system could be extended to small scale buyers, such as restaurants. This has been attempted and discussed in several countries, including the Bahamas and Turks and Caicos Islands, but there are difficulties with starting or sustaining such systems. There are usually large numbers of small scale businesses, many of which would not have computerized data systems, and therefore require more support from fisheries departments.

For larger vessels, there is clearly an opportunity to set up a log-book programme as used for example in Jamaica. These are not widely used in the region, although they are standard practice in most developed country fisheries around the world. Requiring that larger vessels complete log-books as part of their licence conditions is not an unreasonable requirement.

To record other catches that are not landed at processors, such as subsistence catches or catches sold directly to restaurants, food outlets and the public, the majority of data are collected through trip interviews at landing sites. This type of data collection is not set up solely for conch landings, but would record all fishing activity and catches at landing sites sampled at random. Therefore this data collection would provide catch and effort data for all fisheries.

A trip sampling program is operated successfully by St. Lucia over a wide range of landing sites across the island. Part of the success of this programme is due to employing local residents at each site to record data, which makes recording consistent and minimises the number gaps in the data. All catches can be raised to totals from the sampling.

A critical component of trip sampling is the "raising factor", which determines how catches should be raised from the sample to the estimated total. This can sometimes be made an overly complex procedure, and inaccuracies and difficulties with this process may put off countries from developing this type of system. For the Bahamas, although there is a trip interview system, no attempt has been made so far to organise the sampling so that the total catch can be estimated.

Traditionally, and following FAO guidelines (FAO 1999), total catches can be estimated based on frame surveys of the fishing fleet completed every 5 years. Such frame surveys are expensive and most countries do not succeed in carrying them out frequently enough. However, while frame surveys in many instances are ideal, they are not the only way to raise estimates. Raising factors can be based on any fixed number from which the sample is taken. For example, if the possible 20 landing sites within a week of 6 days are sampled at random (20*6=120 possible sample units), then as long as correct data are recorded from each sample unit (the total vessel-days fished and catch landed) and a sufficiently large sample taken (at least 11 site-days), the total catch (and sampling error) for the week can be estimated very simply.

If the fishery cannot be made to report landings and they cannot be sampled by fisheries staff, then monitoring becomes very much more difficult or impossible. In these cases, the first task is to assess the proportion of the catch which remains unrecorded. If it can be shown that these catches are only a small proportion of the total catch, it may be possible to argue that the harvest strategy is robust to the uncertainty they introduce. This should be properly tested using scientific approaches, but it is worth bearing in mind that most problems are caused by changes in unrecorded catch rather than the absolute quantity. So, for example, a consistent unrecorded catch of 10% of the recorded landings is not likely to cause a problem for a control based on a landings limit, but if the unrecorded catch was increasing over time, even if less than 10%, it could bring about undetected overfishing if such catches were not controlled.

Determining the scale and possible trends in unrecorded catch would depend upon what type of catches these are.

- Subsistence and catches sold locally: All catches destined for local consumption can be estimated through consumption surveys. In some countries these are conducted by health departments anyway, so additional specific questions on fish and conch consumption could be added. Together with estimates of total population and/or tourist visits, the total consumption can be estimated. It should be noted, however, that this approach has not been used very much in the region, and where it has been used, in the Turks and Caicos Islands, estimates of consumption were imprecise (CRFM 2007).
- IUU catch: This, by definition, cannot be estimated accurately. Jamaica reports IUU catch on the Pedro Bank is significant, but does not report quantitative values. Direct estimates from interviews with fishers are not recommended because fishers are not disinterested and will give biased estimates. Estimates from other means have not been attempted, but could in theory be estimated imprecisely by mapping the space and time of opportunity for IUU, the proportion of that space and time period which is observed and, together with the legal fishery catch rates, therefore estimate the possible range of IUU catches. Estimates of total mortality (Z) would also

include IUU fishing, although it may be difficult to separate mortality between the legal and illegal fisheries.

Based on the assessment of available information, it should be possible to determine what new information is required and how that information might be obtained in the most cost-effective manner in each case. If it can be demonstrated that the proportion of the unrecorded catches is low and not increasing, then it may also be determined that continuous monitoring is not required.

Case Study: The Bahamas Data Collection Initiatives

In 2012, a new data collection system was initiated to obtain catch and effort data from the main processors who export, as well as supply larger local restaurants, lobster, conch and fish. The system was primarily set up to improve the provision of accurate data for spiny lobster, but will cover all marine products purchased by the main processors. Implementation is not complete: data are not yet routinely processed by the Department of Marine Resources (DMR) and only one processor has consistently submitted records so far.

The data collection method is based on spreadsheet data entry forms. These include various features to minimise mistakes and aid efficient data entry. The spreadsheet provides for the regular weekly transmission of data from the processor to the DMR by email. At the DMR, the spreadsheets can be loaded directly and automatically into an MS Access database with minimum DMR staff intervention. The process relies on familiarity of staff in the processing facilities with MS Excel (which is used by them anyway), and MS Office software's ability to integrate and automate processes.

Although processors were already transmitting spreadsheets of total production data, the breakdown of catch and effort by trip was not being collected. Collecting the additional data has required more work for the processors, but as in some cases they required an EU catch certificate anyway and the DMR has provided software tools to help in data entry and preparation, the additional work is not excessive.

Traceability (Catch Documentation Schemes)

Ensuring that catches are traceable is an important tool for combating illegal, unreported and unregulated (IUU) fishing activities. Generally, traceability within the trade depends upon catch documentation schemes (CDS). CDS can not only help prevent IUU fishing, but can also be designed to enforce some catch based controls and to aid accurate data collection. Some CRFM countries are familiar with the CDS used by ICCAT and the European Union (EU). For developing a scheme in the Caribbean, it makes sense to consider the EU IUU regulation which is already in use by those states which export fish products to the European Union.

Any scheme will need to consider its performance based on the following criteria (Clarke 2010):

- Inclusivity - the extent to which the scheme is designed to provide documentation for all legally caught fish of the species/fishery in question. For queen conch, this would imply a CDS covering all conch caught in the region, not just in CRFM countries. It may be difficult to cover conch caught for local consumption, but this might be at least partially addressed through defining reporting requirements at national and international levels.
- Impermeability - the extent to which the scheme is designed to exclude illegal fish. This might be achieved through cooperation from the trade and trade organisations, third party importers and through regional auditing.
- Verifiability - the extent to which the scheme is audited by those other than the parties directly responsible for filling out and validating the forms. By adopting a regional approach, independent auditing of catch exports is possible by appropriate regional organisations that might be given the mandate.

Other areas include checks on a vessel‘s authorisation to fish and registration number; stricter rules for traceability of split catches and shipments; prohibition against re-directed rejected shipments; and periodic, empirically-based programme reviews.

Any documentation scheme should be catch based not only trade based. That is, product should, as far as possible, be traced back to a particular trip and the location caught. Verification of location caught may not be possible on vessels with a GPS based monitoring system, so would not be applicable to conch. However, given that the majority of catches are made by local vessels in CARIFORUM states, linking the document to a trip should be adequate.

Scheme objectives should include catch monitoring, scientific information and traceability. Catch based schemes not only support traceability, but have great potential for monitoring compliance with management measures, including total allowable catch limits, if they are implemented. However, these uses may provide an incentive to falsify landings data, so verification will become more important.

It is important to get wide agreement on implementation of a CDS. Weaknesses in the CDS would arise from flag, port or trade States refuse to participate, or fail to implement all components of the scheme in a rigorous manner. This means the scheme should aspire to apply best practice, but take account of the technical abilities of the businesses and government departments concerned.

Brief Outline of the EU IUU Regulation

The EU enacted Council Regulation (EU) 1005/2008 in September 2008 (European Union 2008) and implemented it in January 2010. The EU IUU regulation requires catch documentation for all fish trade into the EU. The regulation features elements of port State measures such as prior notification of landing, catch certification and vessel blacklists, but also incorporates elements of catch documentation schemes like CCAMLR‘s and ICCAT‘s by requiring documents proving the legality of the catch before authorising its import to the EU. Although its elements are not new, CR 1005/2008 is likely to have a great impact on fish trade, because it applies to all wild-caught marine fish, other than ornamental species, imported to the EU. The regulation mainly applies to the trade of fish caught by EU-flagged vessels if those fish are first landed in a third country and then imported to the EU (e.g. Spanish-caught Indian Ocean tuna landed in Mauritius for processing and exported to the EU). The potential for the EU‘s IUU regulation to create discriminatory trade barriers, as well as the cost and capacity burden associated with compliance, are major concerns among developing countries (ACP 2009). The ICCAT CDP have been recognised as being in compliance with the requirements of the EU IUU regulation.

Development of new schemes should take account of and aim to fulfil the requirements of the EU IUU regulation. The EU IUU regulation probably represents a minimum requirement for an effective CDS, which should be exceeded if possible. The regulation does not require unique document numbers, electronic document systems, the catch location or third party audit/oversight. However, all catches need to be linked to specific vessels and trips, and this must be verified by the appropriate government authority (i.e. the fisheries department). While the documentation system is straightforward, the information it relies upon is potentially difficult to collect and verify by CARIFORUM countries without support.

Case Study: The Bahamas EU Catch Certificate

Exporters from the Bahamas to the EU require a catch certificate, which is provided by the Department of Marine Resources. Currently the certificate is compiled by hand, copying and pasting the trip records provided by the exporting company into a document. Although this relies solely on information provided by the exporter, there is no incentive to provide incorrect information and certificates are only issued to a few reputable, licenced processors.

To improve the provision of catch and effort data, this process has been partially automated, making use of spreadsheets for data entry and transmission, and a simple database to hold and report data (see above).

Part of this new data collection initiative addresses the provision of a catch certificate. A catch certificate request can be automatically verified based on data previously provided, as well as automatically produced and printed both in paper and electronic form.

A significant advantage of the system is that it works using office software and systems with which processing company staff are already familiar. Most data in businesses are managed on spreadsheets which have become very powerful. More complicated data still require databases, which would enhance data management for this and other purposes, but most company staff are not familiar with database management. This does not mean that training and technical support are not required. At the very least, staff needs to be introduced to the requirements and how the system can be used to meet these. However, the software can incorporate help and guide users in applying the correct methodology.

Although the system manages information more efficiently, the information itself still needs to be verified. This can be done at various points in the chain of custody, where the quantity of conch can be measured and matched against the quantity recorded on the certificate. Critical points of verification include the landing site / delivery point to the processor, the point of export and the point of import. Verification in the Bahamas is not carried out at the landing site and only superficially at point of export.

Catch documentation systems (CDS) generally have two documents associated with each shipment: a catch document required when fish are transhipped, landed, imported, exported and re-exported; and an export/re-export document required when fish are traded internationally after landing. Documents could be required for all catches of queen conch with the possible exception of artisanal catches which are not exported, but for which annual reporting of exempted quantities could be required.

All CDS documents should be validated by the relevant government authority. In order to be compatible with the EU IUU regulation, catch documents will have to be validated by the vessel flag State, which in these cases would be the same state having jurisdiction over the resource.

RFMOs, such as CCAMLR and ICCAT, commonly co-ordinate CDS and compile information for validation purposes. There is a clear opportunity for CRFM, as a key regional fisheries body, to support the development of a CDS within the region. All landings and export/re-export documents would have to be validated. To further develop a regional system, all validated documents issued and received would be copied to the CRFM Secretariat. CRFM would be responsible for maintaining catch documents in a database to help countries validate imports and exports, and would need additional resources and staff to carry out this task. Special provision may be needed for importing countries outside the region (EU, USA) to be included in the CDS. Such a system would make it much harder for illegal catches to penetrate the scheme.

Systems that require a chain of custody usually audit each trader to ensure they apply good practice in maintaining documentation of their fish products. Most countries and traders that export fish products are already familiar with similar procedures, which are also required under quality controls, such as HACCP (Hazard Analysis and Critical Control Points).

Processing Conversion Factors

Most conch fisheries will produce conch meat to different levels of "cleaning". This can make a dramatic difference in reported catches, with live weight as required by FAO which includes the shell weight being an order of magnitude greater than 100% cleaned which is often reported in trade data (Aspra *et al.* 2009). Clearly, for any catch documentation system as well as stock assessment, it must be possible to link and convert between different processing levels to maintain a consistent interpretation and apply control over exports. While some countries have estimated conversion factors, such estimation has not been standardised or necessarily rigorous.

Currently, such processing depends only upon industry needs and there is no regulation. However, it needs to be considered whether processing at sea must be limited since this makes monitoring significantly harder. Therefore, it is worth considering whether standard levels of processing could be defined in regulations and enforced:

1. Require conch to be landed to particular cleaned levels. Landing requirements might cover:
    a. Landing uncleaned in the shell, which might be suitable for subsistence or recreational fishers without a commercial licence.
    b. Landing cleaned but to a limited level, so certain measurements may be taken. These could include landing with the operculum still attached or sufficient skin to identify the sex and maturity. However, some sort of processing would be required after landing which could increase costs.
    c. Landing 100% cleaned, but only where an observer is aboard to collect samples. Most vessels are too small to take observers.
    d. Landing 100% cleaned, but reserve a proportion uncleaned for monitoring purposes (such as the last day's fishing or 5% catch). However, some sort of processing would still be required after landing which could increase costs.
2. For each allowable processing level, collect samples over a range of months and years to convert processed meat to whole meat.
3. For conversion to live weight with the shell, multiply the unprocessed weight by 5.7 throughout the region (Aspra *et al.* 2009), which would also need to be applied retrospectively to past landings. This would only need updating if shells as well as meat exports became substantial, so different streams of export data would need to be reconciled. With the exception of the requirement of FAO to report live weight, the actual weight of conch with the shell on is of little value in most fisheries.

Conversion factors can be estimated based on standard scientific and statistical methods. Estimates should be unbiased, which can be achieved by random and stratified sampling. The parameter to be estimated is the proportional change in weight (a_p) for converting the processed weight (W_p) to unprocessed weight (W_u).

$$W_u = a_p W_p$$

The parameter (a_p) would need to be estimated for each allowable processing level. Sampling and the estimation should address the following issues:

- Precision: The required precision on the estimated parameter should be defined. The error on the estimated total catch should be less than 2% of the unprocessed weight.
- Size: The sampling needs to cover the full range of sizes that are landed. Samples covering only a small range of sizes will estimate the parameter very poorly.
- Seasonal effect: The sampling needs to cover the full period that landings are made. There is likely to be some seasonal impact on conch size, so samples should cover the full fishing season and estimation should remove any bias if samples are not equal across the season.
- Time: The sampling should be periodically repeated to ensure changes in the parameter are detected and accounted for. Sampling after the initial estimation can be considerably reduced.
- Other factors: Factors that affect the relationship between processed and unprocessed meat weight could include sex and maturity. These can be recorded and accounted for to ensure that no bias is introduced in the overall estimate. However, other factors are unlikely to be a significant source of error.

Some work has been conducted in the Dominican Republic, Honduras and Nicaragua to define conversion factors from processing grades to FAO live weight requirements (Aspra *et al.* 2009). This type of work can easily be extended, but be developed to convert between standard national or regional processing grades across the region.

The Bahamas have some data, and have developed conversion factors, but the method and data have not been published. Data are easily collected with the co-operation of the processors, and with rigorous sampling across a year. Data could be bought to the CRFM scientific meeting where they could be analysed by the Conch and Lobster Working Group and subsequently published to ensure conversion factors are clearly understood and applied consistently across the region.

Abundance Data

Data Collection

There are currently two methods for collecting information on conch abundance that are widely used. Fishery-independent visual surveys employ divers to count conch on randomly placed transects over the conch population range. Fishery dependent catch and fishing effort can be used to calculate catch-per-unit-effort (CPUE). In the Turks and Caicos Islands, Jamaica and Belize, both indices have been reported. The only other realistic option for generating abundance indices would be a tagging program. Tagging has been carried out in many countries, primarily for research purposes. To use tagging to generate an index, an extensive program would be needed. Tagging data are by far the best indices if some basic requirements are met. Tagging should not affect growth or mortality (unless this effect can be estimated) and all tags should be returned at recapture. While tagging the shell will have a negligible impact on the conch growth and mortality, if the shell is discarded at sea, it is unlikely all tags that are recaptured will be returned. This makes an effective tagging program difficult to implement.

Many smaller fisheries do not have any abundance information. For example, St. Kitts and Nevis and Grenada have no abundance index. The fisheries are small and costs of collecting conch-specific abundance data are prohibitive. For these countries, the only cost effective approach would be catch and effort data, but only if the index covered all fisheries as well as that targeting conch.

Surveys

Because conch are large shells easily found in shallow water, they lend themselves to fishery independent surveys. Although such surveys are labour intensive, they require equipment and skills commonly found in islands where conch are exploited. Although an attractive method, particularly where historical data are lacking, it is important that the benefits of such surveys as a measure of abundance are properly understood. In particular, it is important not to overestimate their accuracy in estimating absolute abundance. Surveys are not "stock assessments" in the sense that they do not provide information on stock dynamics, only estimates of the current biomass and stock structure. To interpret this information so that catch limits can be set, some level of productivity of the stock has to be assumed or estimated. A survey alone is not sufficient for this.

The survey data can be used in four ways:

1. as a direct estimate of abundance,
2. within a stock assessment to index abundance,
3. as a direct estimate of density of mature animals, or
4. to assess densities under different management controls in different areas (e.g. MPAs).

Surveys are used by Belize and Jamaica to help set catch limits. The Turks and Caicos Islands has been planning to repeat a survey carried out in 2001, if they can obtain the financial resources. Surveys are not only used to measure abundance (biomass), but also provide information on population structure and density. This informs the decisions on setting catch limits which are adjusted in response to the survey

information. A Belize national conch survey was carried out during the period August 15 to September 15, 2012.

A biomass survey will make interpretation of catch and effort easier as well as providing estimates of indicators and reference points. Total catch divided by total biomass gives some indication of the exploitation rate. QCEW (2012) provides some guidance on how to use this information, suggesting that if catches are below 8% of the survey biomass and average density of conch is well above 100 per hectare, the population is at a safe level.

If no full stock assessment is available, a default 8% of the estimated mean or median fishable biomass can be used to set a precautionary sustainable yield if only estimates of biomass are available and the stock is not depleted (QCEW 2012). This option might be useful in some countries with no stock assessment to check that current exports are sustainable. In theory, a single survey could show that the exploitation rate is much lower than any candidate MSY reference point, for example, and therefore further research is unnecessary as long as catches are monitored.

If catches are found to be greater than 8% of the estimated biomass, further development of a harvest strategy would be required. These fisheries will need to develop precautionary harvest levels based on scientific research and the on-going evaluation of their harvest strategy.

The 8% value can be adjusted to apply greater precaution or as a result of credible science which shows that the stock is more or less productive than this. The 8% catch was proposed as precautionary reference point because if the biomass estimate and the derived yield are based on the surveyed area only, they are likely to underestimate the true population size. Survey abundance estimates should not be extrapolated to areas that were not included in the survey.

Surveys can also be used to check that spawning densities are above critical levels. Where a reference point is required for the median or mean density estimated from surveys, 100 adult conch per hectare (or higher) should be used (QCEW 2012). When the median or mean density falls below this level, there is a significant risk that recruitment might be impaired, and therefore special management action might be required to rebuild density above this level. It should be noted that to use this reference point, the survey area will clearly need to cover the spawning stock.

If a management strategy is to be developed on the basis of a survey, care must be taken to ensure that the survey is accurate and unbiased. Surveys are most likely to be negatively biased, so that they underestimate the stock biomass. While this may lead to precautionary catch limits, there is the obvious problem that the catch limit may be much lower than the fishing industry or communities are prepared to accept. This would likely lead to the survey being rejected or ignored, worsening the management system. Any survey should at least cover the known fishing area with depth stratification. This is the approach used in both Jamaica and Belize, and other countries. As better information becomes available, the survey area could be expanded to include additional areas based on habitat, which might cover unexploited parts of the population such as juveniles or deeper water spawning stock.

It is important to document and publish any survey or stock assessment, if possible. In some cases, surveys are available in the public domain, but this is not true for all surveys. Publishing, at the CRFM Scientific Meeting for example, has several strong benefits:

- It will reduce uninformed comments and recommendations which may be made on conch fisheries from time to time,
- It will improve the co-ordination and effectiveness of various management controls by allowing the comparison of information on the distribution of maturity and size composition, as well as appropriate estimates of abundance and reference points that might be obtained from meta-analysis.

- Publishing helps share experience in designing surveys, data collection and other analysis. This will lead more quickly to improvements in methodology.

Case Study: Belize and Jamaica Abundance Surveys

Jamaica's and Belize's main research activity on conch is to conduct abundance surveys every 3 to 5 years to determine conch density and overall abundance. These inform harvest strategy and future management decisions, including allowable catches and exports. Surveys consist of visual transects placed in depth strata. Surveys only go to 30m depth, although conch may be found below this depth.

All conch are counted within a particular transect area, and allocated as far as possible to size/age groups (e.g. juvenile, pre-adult, mature and stoned). This gives estimates of density and, by multiplying by the whole survey area, raise to total abundance. To estimate biomass, a sample of the conch which are encountered is collected at random, measured and weighed.

One of the reasons that Jamaica decided to use fishery independent surveys was because very little scientific work was done prior to 1994 when the first abundance survey was done. In fact, the first assessment of Jamaica's Queen Conch stock had to be based on literature reviews, interviews and workshops conducted jointly by the CARICOM Fisheries Resources Assessment & Management Programme (CFRAMP) and Fisheries Division in 1992 (Aiken *et al*., 2006).

Neither Belize nor Jamaica have developed alternative abundance indices yet. An alternative CPUE index may be less expensive, but would not provide the same level of detail on stock structure.

Both Jamaica and Belize have spatial components to their harvest strategy. Belize has extensive protected areas over their barrier reef and related habitats which contain substantial numbers of conch. The surveys are used to monitor conch within these protected areas. Jamaica applies rules which limit effort within particular areas to ensure conch populations are not subject to serial depletion. This can be enforced using VMS.

Table 1. Estimates of density for each depth strata and total Queen Conch biomass on the Pedro Bank (Jamaica) for each survey year (updated from CRFM 2006, 2012a).

Survey Year	Depth Strata (m)	Density Estimate (Conch ha^{-1})	Biomass Estimate (t)	Source
1994	0-10 10-20 20-30	73 152 203	13,325	Appeldoorn (1995)
1997	0-10 10-20 20-30	175 88	12,203	Tewfik and Appeldoorn (1998)
2002	0-10 10-20 20-30	 138 244	15,306	Smikle and Appledoorn (2003)
2007	0-10 10-20 20-30	378 49 50	7,421	Unpublished data
2011	0-10 10-20 20-30	243 145 165	12,214	Unpublished data

Catch per Unit Effort

Long term monitoring would depend on being able to generate annual catch-per-unit effort (CPUE) by fishing ground. CPUE is usually the least expensive method, can be maintained over a long continuous period and large amounts of data can be generated. Data quality may be an issue, however, because data are not recorded based on any scientific design.

Measuring effort is a particular problem. Most fisheries will consist of many trips where multiple species are collected and landed together. Some unknown proportion of the effort within the trip should be allocated to the capture of conch, but without this figure, such trips cannot be used in CPUE indices without significant loss of precision and possible bias.

For export fisheries, it seems reasonable to require catch and effort data to be collected, so that the fishing industry must provide necessary information as part of their licence condition. These data can be used to provide abundance information in the absence of surveys, to confirm survey trends or as guidance between infrequent surveys as well as information for different analyses such as bioeconomics assessments. They may also provide a lower cost replacement for surveys as an abundance index.

An important requirement of abundance indices is that they be consistent from year to year. The main concern with using CPUE is that there will be changes in catchability. Catchability is the scaling parameter between biomass and the CPUE variable. It can change if vessels become more efficient, for example, or if management controls the way vessels fish (e.g. introducing a minimum size control). Improving gear and equipment may lead to changing increases catchability, which will invalidate the abundance index. This is less likely to be a problem in artisanal fisheries where gear improvements are limited. Nevertheless, to account for changes in catchability, measures of fishing power as well as other relevant data for purposes of standardisation should be collected.

Another reason why catchability may change is due to management intervention. In some circumstances, management may take action to reduce catchability (e.g. limit the use of compressed air, or implement closed areas) which also could affect the index. Stock surveys can be used to bridge such changes.

Countries have encountered significant problems in collecting catch and effort data. The diffuse nature of the landings makes monitoring catches (and effort) difficult, but not impossible. The approaches follow those used to estimate total catch, and include processors being required to submit forms containing catch and effort data (The Bahamas, Belize), trip interviews (St. Lucia, Dominican Republic, The Bahamas) and log-books (Jamaica). Some countries, such as Grenada do not collect these data. One advantage of catch effort data is that the data need not be raised to a total, and therefore can be collected without a frame survey. The analyses that use these data may also be robust to breaks in the time series, although these would add to the uncertainty in any results.

Stock assessments require contrasts in the data in terms of population depletion and growth to allow accurate estimates of appropriate controls. Although periods of depletion may not be considered desirable, periods of reduced fishing mortality once monitoring is in place could be applied to see whether the population increases in response, and at what rate. This need not be over the entire fished area, or for a very long period. This sort of adaptive management is particularly valuable in determining the best exploitation level.

Abundance surveys can be used alongside CPUE to improve the CPUE index. The Turks and Caicos Islands carried out a survey in 2001 which estimated the exploitable biomass. The estimate confirmed the biomass estimate from CPUE data. However, Turks and Caicos Islands have a particularly informative CPUE index because it covers such a long period. In other circumstances, an abundance survey can be used to estimate the absolute stock size, and the CPUE index can be used separately to estimate trends in abundance.

Assuming that CPUE is tracking absolute abundance, it can be used as a robust indicator of stock status and as the basis for simple harvest control rules. For example, maintaining CPUE above 50% of the unexploited CPUE could be a well-defined trigger point for the fishery. If CPUE falls below this point a rebuilding programme can be implemented.

Case Study: Catch and Effort Based Data for the Turks and Caicos and The Bahamas

Turks and Caicos Islands conch fishery has a relatively homogeneous fleet of small artisanal vessels with 2-3 crew who operate on single day trips targeting conch or lobster separately and land at 5-6 processing facilities (CRFM 2007). The fishery has been carried out in much the same fashion since the 1970s, so the CPUE has been relatively consistent and appears to provide a good index of abundance. The CPUE index is based on boat days. It was found that the number of crew (2 or 3) did not affect the catch rate (Medley and Ninnes 1999). This makes the data collection very straightforward. The processors are required to complete a data collection form for each month which records only the quantity of conch (or lobster) purchased from each fisher on each day. Each day's landing for each fisher represents one boat day of effort. Other more complicated information on trip length or alternative fishing activities is not required, making data records simple to record and interpret.

The Bahamas, which has fisheries operating in an environment very similar to the Turks and Caicos Islands, has a more heterogeneous fishery, making a CPUE index more difficult to measure and/or less reliable. Some Bahamian operations consist of larger vessels which process catch at sea. Also, in many cases, several species are fished during a trip. Strictly speaking, complex information concerning activities within a trip should be recorded. In practice, only the trip length is being recorded for each vessel. Auxiliary information on the vessel (its size, crew and so on) can be derived from other sources, but if landings consist of mixed species, a reliable effort measure is still not possible. However, even with only trip length, it is possible to identify homogeneous sets of catch and effort which can be extracted and used. For example, vessels recorded as landing catches of greater than 90% conch with a trip length of up to 5 days might be selected to obtain the CPUE. This is not fully efficient in the sense that much of the data that have been collected are rejected, but it may produce a reliable index.

The Bahamas collects data from two sources. Processing facilities are beginning to submit data in electronic form which includes the identity of the vessel and the trip length as well as quantity of catch purchased. Expecting processors to collect more information on fishing effort may be unreasonable. The other source of data is from trip interviews, which depends upon co-operation from the fishers. The data from this source is reliable, but not accurate as it depends upon estimates of the catch rather than measured quantities. Trip interviews also may be biased as they concentrate on New Providence Island, whereas conch is landed extensively through the archipelago.

Size Data

Wherever possible, landings should be sampled to provide information on size composition and maturity. While these data may not be critical, they provide useful information for management as well as indices that complement other information from surveys, and catch and effort. Also, where there is a minimum size regulation, sizes should be sampled to indicate the level of compliance.

The previous CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) supported the collection of conch size compositions from landings in a number of countries. CFMC/CFRAMP (1999) reported the outcome of analyses on these data. Jamaica has carried out routine size composition both as part of the survey and of landings. Jamaica's annual conch catch statistics are collected as part of the national fishery sampling and data collection plan, which includes catch and effort and biological sampling. Authorized officers from the relevant agency collect data at critical points of harvest, pre- and post-processing, and export.

While size composition data of various sorts has a role in general monitoring of fishery performance, their value in stock assessment is limited. A significant problem for all fisheries is the limits on what can be measured. Many growth models linking size to age have focused on the shell (Ehrhardt and Valle-Esquivel 2008), but in many fisheries the shell is not landed and may even be removed underwater. If the shell is removed, not only can data not be collected on it, but regulations specific to shell size or lip thickness cannot be enforced.

All fisheries land meat at different levels of processing. Therefore, meat weight is the only size measure that can be universally taken across all fisheries. CFMC/CFRAMP (1999) reported an analysis that linked weight to age. This would allow catches to be separated into cohorts (conch of the same age), which can then be used in a standard stock assessment method, cohort analysis. Weight based cohort analysis has been used in the Bahamas, Belize and Jamaica, but this method has not been applied recently. The CFMC/CFRAMP (1999) workshop also reported that growth and mortality vary considerably and may be density dependent. This makes linking size to age based on meat weight alone untested and highly uncertain.

The reason why monitoring programs have persisted with the intention of collecting size data despite the problems associated with it is that for many small scale fisheries it would be a very useful monitoring tool if it could be made to work. Periodic infrequent collection of size data may be possible in many fisheries. A harvest strategy could be based on such a data collection program if a clear interpretation of the data were available to indicate whether or not a catch reduction was required.

Given what is known of conch biology and ecology, it remains unclear whether there is a robust strategy based on the size data that can be collected in various countries. It is clear that the various size measures do indicate exploitation levels, but separating these from other complicating features that vary from fishery to fishery, such as selectivity, density dependent growth and variations in mortality, has probably not been achieved.

Although it is currently not known what would be required to make available size data useful, it is possible to consider what measures are most likely to work and whether it would be possible to collect these data. Processed meat weight is the most unreliable measure of age. Not only can it not be verified that meat is closely related to age except in the juvenile stage (Ehrhardt and Valle-Esquivel, 2008), but processing itself introduces more noise into the measure (Aspra *et al*. 2009). Conversely, shells are probably the best measure of age in adults, but rarely available. Therefore, data on meat weight alone should not be relied upon for stock assessment purposes, but there is no reason why such data should not form part of a system for monitoring and control.

Some requirement may have to be placed on what is landed for monitoring purposes. Realistically, this may only be a proportion of the catch, depending on the operation. Research is required to determine what a reasonable requirement might be. Options to be considered might be landing the shell, landing uncleaned meat, or landing the operculum or other parts of the conch "trimmings". For example, measurements taken before processing (only the digestive glands removed) allows the maturity and sex to be recorded.

Size data has been collected routinely in all abundance surveys. In abundance surveys it is always necessary to obtain size information so that biomass and age structure of the population can be determined.

Data Analyses

Data analyses provide scientific information to help with decision-making and evaluate management against its objectives. The analyses which can be applied mostly depend upon the data available. Since an

analysis provides a link between data collected and the scientific advice, the harvest strategy will need to consider not only what data can be collected, but how that might be linked to the type of advice required to meet fishery objectives.

In general, there have been few reviewed stock assessments for conch in the region (Table 2), which weakens the science underpinning management advice. Furthermore, scientific advice is not necessarily clearly laid out. For example, assessments do not necessarily define stock status against well-defined reference points, which is best practice in fishery science.

Most recent assessment have been published through the CRFM scientific meeting (St. Lucia, Turks and Caicos Islands). The CRFM scientific reports provide a useful standard structure for the scientific advice. Other assessments, particularly those based on surveys, have mostly been published through internal reports (Belize, Jamaica). Many countries have no recent assessment, since data was analysed in CFMC/CFRAMP (1999) (The Bahamas, Grenada, Dominican Republic).

Two types of assessment have been applied:

1. Biomass dynamics models require on catch and abundance information. They have been used to guide catch limits based on abundance surveys as well as fitted to catch and effort data. These are simple, but robust models, and provide a useful data-limited approach.
2. The size based methods which have been applied are weight-converted catch curve and weight-based cohort analysis, where catch data are converted from weight to age through a growth model. Size-based assessments have had less success and it is not clear how reliable they are.

Biomass dynamics models are good for setting catch and effort limits, but are poor at providing advice on size (minimum size), technical (no compressed air) or area (MPAs) based controls. However, such an assessment may still, to an extent, evaluate such controls where the objective of the MPA, size limit or gear prohibition is to improve the status of the stock.

Table 2 Reported stock status and assessments for conch in the Caribbean.

Country	Year	Stock Status	Data / Method	Source
Belize	2010	There is no evidence of stock decline and recent abundance surveys indicate high stock size. Fishing effort has increased, so there has been some small increase in risk.	Total catch Fishery independent visual survey	BCFU (2010)
Jamaica	2011	There is no evidence of stock decline. The recent estimated fishing mortality for the legal fishery was less than 0.05 $year^{-1}$. The main concern is IUU catch.	Total catch Fishery independent visual survey	Unpublished data
Bahamas	1998	A size based stock assessment in 1999 indicated that the stock was not overfished. However, recent surveys suggest that the stock abundance has declined, at least at some grounds close to fishing harbours.	Total catch Meat weight catch samples Weight based catch curve and cohort analysis	Ehrhardt and Deleveaux (1999)
Turks and Caicos Islands	2010	Although in a good state in 2006, hurricanes in 2008 appear to have reduced catch rates to historically low levels. The total allowable catch has been very significantly reduced to allow the stock to increase.	Catch and effort data Biomass dynamics model	CRFM (2007) CRFM (2010) Unpublished data
St. Lucia	2008	The stock was overfished in 2008. The estimated catch exceeded the	Catch and effort data from trip	CRFM(2009)

		recommended catch from the stock assessment, implying CPUE might continue to decline.	interviews Biomass dynamics model	

Size based models generally estimate fishing mortality, which can be compared to fishing mortality reference points, such as those that can be obtained from per-recruit models. These will give general guidance on whether fishing needs to be reduced or can increase, and approximately by how much.
Size based assessments depend on a good growth model. There is a good growth model for the shell, but the meat weight model strongly implies that meat weight is uninformative on age for adult conch. This is likely to limit the applicability of more sophisticated methods, such as cohort analysis.

Another problem with interpreting size data is the fishery selectivity. One of the arguments for sustainability in the Belize fishery is that the conch are taken before maturity, but mature conch in deeper water are not exploited. This implies that there is a domed shaped (rather than logistic) selectivity curve, and that fewer larger conch are in the catches not because the stock is overfished, but because larger conch are not being so heavily exploited. This is consistent with the available information, but makes it difficult to assess a maximum sustainable yield. Discriminating between these two cases is difficult with only data sampled from catches.

Finally, it is likely that natural mortality declines significantly with increasing age (Appeldoorn 1988a, b), but quantitative information on natural mortality is limited. This will tend to increase the proportion of adults in the unexploited population and, if not accounted for, lead to fishing mortality reference points which are too high.

These problems may not stop simpler size-based indicators being used, however. For example, mean size measures or ratios between mature and immature conch in the catch may provide a useful measure of the state of the stock, if appropriate reference points can be developed. Development of reference points for such indices would depend upon a reliable stock assessment as well as assumptions.

Therefore, while there has been some progress in conch research, conch stock assessment methods have not progressed since CFMC/CFRAMP (1999). It seems unlikely further progression will be made until growth models and analyses match better the data which can be collected from these fisheries.

Both Jamaica and Turks and Caicos Islands (Lockhart and Seijo 2010) have carried out bioeconomic assessments of their fisheries. These are extensions of stock assessment that allow the preparation of decision tables to aid decision making. Decision tables suggesting an appropriate precautionary long term yield based on bio-economic logistic biomass dynamics model. If they are found useful, this activity should be used more extensively. However, decision tables are most effective when the management authority defines the decision to be made, which has not been the case.

New approaches are required to link the data that can be collected to robust harvest strategies that are credible and can be implemented. Decision tables are one of a number of techniques to provide robust advice when there is limited data and therefore an increased focus on risk. Other approaches are available and should be considered, but tools in form of computer simulations are required to test them (QCEW 2012).

Case Study: Belize and Jamaica

Both Belize and Jamaica apply the same method to estimate the sustainable yield from their fisheries based on single survey estimates of biomass. These provide an estimate of replacement yield based on underlying models, with some assumed parameters. It is important to note that the harvest strategy does not depend only upon the accuracy of these numbers, but along with estimates of density and abundance of the different age groups in the population, they are used to guide allowable catches.

In Jamaica's surveys, not all depth strata have been sampled in every year, primarily due to cost and logistical limits. Belize also used preliminary estimates of fishing mortality from a cohort analysis type approach of the size composition (BCFU 2010). However, mortality estimates appear to vary considerably from age to age.

The surveys have shown some changes in abundance estimates, which may be attributable to observation error rather than true changes in abundance. All surveys have attempted to estimate sample errors, but unless they are combined with a population model, separating different sources of error will be difficult. This has not been done.

The implication is that judicious use of single survey data by itself might be used to guide exploitation levels, either to initiate a management system or for on-going monitoring as in Belize and Jamaica's case.

Case Study: The Bahamas

Ehrhardt and Deleveaux (1999) carried out a stock assessment based on size composition and catch and data for the main conch fisheries of The Bahamas. They employed a Gompertz growth model for meat weight which has a different growth form to the von Bertalanffy growth used in most fish stocks. Growth is generally complicated by the different morphometric measures which are used to re-construct age and maturity (Appeldoorn 1988). Ehrhardt and Deleveaux (1999) constructed a simpler model based on meat weight only. Unfortunately, meat weight by itself is a poor indicator of age in mature animals, but used in conjunction with better known juvenile growth, the authors suggested that a meaningful assessment based on meat weight could be completed. A weight-converted catch curve and "tuned" weight-based cohort analysis were used to indicate fishing mortality compared to fishing mortality at MSY. The findings indicated that the stock was not being overfished at that time.

However, Ehrhardt and Deleveaux (1999) noted that the high proportion of juveniles in the landings could increase risks to the fisheries in the Bahamas and therefore implied that improvements in compliance were warranted.

Case Study: Turks and Caicos Islands

The Turks and Caicos Islands has a catch and effort data set that extends back to the mid-1970s and total catch data to the early 1900s and before. This is perhaps unique in the region as a fishery data time series. These data have allowed a full assessment based on a simple biomass dynamics model, so that the long term sustainable yield can be estimated. There are concerns, as there always are, over the completeness of the catch estimates and whether the CPUE is a good index of abundance, but the model has until 2008 fitted the data well (CRFM 2010). This includes a fishery independent abundance survey in 2001 which estimated close to the same fishable biomass.

However, after the two hurricanes Hanna and Ike hit the Caicos bank in 2008, the CPUE showed a sharp decline in 2010 leading to a large reduction in the allowable catch. The average catch rate 2000-2008 was 493 pounds conch meat per boat day, 2009-2011 it fell to 285 pounds conch meat per boat day. It is thought likely that the hurricanes caused a high mortality among post-settlement larvae and juveniles. The response of the management system, to significantly reduce the catch, was precautionary.

Clearly, the simple assessment model would not be able to predict events such as hurricane mortality, but the CPUE index can nevertheless guide management in rebuilding as the index and reference points from the stock assessment remain valid. The Department of the Environment and Coastal Resources also intends to conduct another abundance survey if they can secure the necessary resources.

Case Study: St. Lucia

In St. Lucia, around 2% of landings are conch, exclusively for local consumption. Therefore, it is not appropriate to expend significant part of the limited department of fisheries resources on this fishery to the detriment of others.

In 2007, a stock assessment was undertaken using the available catch and effort data (CRFM 2007). It is important to note that the data collection system, consisting of trip interviews at landing sites, covers all fisheries, so that data that was used was not specific to conch. However, conch directed effort could be identified within the data set due to the way effort was recorded. These data provided a time series of total catch and effort data (based on air tanks used) suitable for a biomass dynamics model stock assessment. As well as these data, information was drawn from other fisheries and some expert judgement to complete the assessment. The stock assessment gave the current state of the stock and provided an indication of what a safe sustainable yield would be.

Management recommendations included improving compliance with current regulations, limiting catches to less than 30 t per year and apply a limited entry policy to prevent any increase in fishing effort. St. Lucia last reported that no progress had been made on these recommendations (CRFM 2009).

Although the stock assessment was able to provide advice despite the limited data available, this has not led to additional management controls on the fishery. Catches exceeded those that were recommended in subsequent years and results suggest the state of the stock have worsened (CRFM 2009). Given the size of the fishery and resources available to the fisheries department, any management initiative would require the co-operation of the fishing community, and to obtain co-operation through co-management is likely also to require the fisheries department to commit resources to this fishery.

Data Management

A number of databases exist to hold fisheries data. CARIFIS is supported by CRFM to hold trip interview data, and is currently being evaluated. Other ad hoc databases exist to hold specific datasets exist in all countries. Some countries do not use CARIFIS and others, in practice, manage their data on spreadsheets (MS Excel). While far from ideal, the complexities of database software and/or databases has proved a significant hurdle for many fisheries departments and staff responsible for data. In most cases, fisheries departments lack the skills and technical expertise to manage databases without external support. It is necessary, for example, to have a basic understanding of the database structure and the Structured Query Language (SQL) to be able to use databases, such as CARIFIS, effectively.

Consideration should be given to the development of a regional database, such as that usually maintained by regional fisheries management bodies. Although additional resources may be required by CRFM to implement such a system, this may help countries develop national databases, where currently they do not have the capacity to do so, as well as support regional ecosystem based management by providing accurate regional data.

Data management should not be underestimated as an issue for improving data and scientific research. Lack of good data management renders many activities inefficient and ineffective, discouraging further data collection and analysis. Significant historical data have been lost. For example, conch data collection has been carried out over a number of years in the 1990s in the Bahamas, but only a small proportion is still available for analysis. These historical data will become increasingly important in developing reference points.

Data that are collected, but not computerised, cannot be analysed. Purchase receipts are routinely completed which provide accurate catch information and may also provide fishing effort. However, unless available in computerized form, these data cannot be used, as in Grenada, for example. Data entry by government staff is expensive and may not be necessary, where businesses can be required to submit data in electronic format.

Given the widespread use of MS Excel, it would seem useful to construct data entry and some management around this software. MS Excel has increasingly advanced data management tools, such as linking to databases for data extraction, pivot tables and other types of relational database table tools that allow basic manipulation of data to achieve common outputs.

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ANNEX 1: The Bahamas Case Study
Background

Country Visit

The country visit was an essential element to conduct the national case study in The Bahamas. The purpose of site visit was to evaluate the possibilities of enhancing scientific research to inform management decisions and to support a sustainable queen conch fishery. A number of activities were performed. Some preliminary analyses were carried out on available country data, to provide a better assessment of problems which would be encountered (Appendix A). A list of the key people interviewed is provided in Appendix B and a summary of the activities conducted in Appendix C.

The main objective of the country visit was to obtain first-hand information about the queen conch fishery, the status of the stock, the data collection practices and the components of the management system. Emphasis was made on evaluating the existing (or necessary) methods to collect and analyse catch and effort data, as well as those to conduct biological surveys or fishery-independent monitoring activities.

The review of the management system included an analysis of the general legal framework, the fishery objectives, the harvest strategy, the research plan, and the monitoring, control and surveillance mechanisms used to ensure compliance with fishery regulations. A checklist of management information was completed during the interviews (Appendix D). Analysis of all of these elements unveiled the strengths and gaps in the system and the management needs for the fishery. These helped to formulate and discuss practical options to improve the scientific basis for queen conch fisheries management in The Bahamas.

The findings from the site visit are summarized in this case study report.

Purpose of the Case Study

The objective of the case study is to improve the scientific approaches required to support sustainable management of queen conch (*Strombus gigas*) in the Bahamas, and in particular, consider options for incorporating scientific information into effective management strategies. The case study will provide information necessary to consider harmonising management within the region which should lead to more effective support and co-operation among CARIFORUM countries.

It is not possible to separate science from the fisheries management completely, since the decision-making process and available management controls have a strong influence on the types of information which might be provided. This report therefore also covers these issues to the extent that they affect the science that might be undertaken.

Description of the Fishery

The conch commercial fishing industry is based primarily on the Little Bahama Bank and areas found in the northern and central sections of the Great Bahama Bank and more recently, Cay Sal Bank. Fishing is primarily carried out with the aid of the air compressor within the depth range of 10-20m and free diving 0-10m. Use of compressed air is prohibited at depths outside of this range and SCUBA diving is outlawed for commercial fishing. The queen conch is primarily collected by hand and is landed mainly as frozen meat in bags and to a lesser extent in the shell.

A fisheries census conducted in 1995 showed that there were approximately 9 300 fulltime fishers and over 4 000 small boats and vessels. The main type of vessel used in the conch fishery are small dinghies (< 20 ft long) which work in conjunction with a larger motorized vessel that act as a base for operations.

Conch has a lower value than spiny lobster, so fishing effort for conch is relatively low during the eight month lobster season and over 66% of recorded conch landings taking place during the four month lobster closed season.

The conch fishery is important socioeconomically. It helps to provide employment, especially during the four month lobster closed season, and provides a traditional source of low fat protein in the Bahamian diet. The majority of conch landings are consumed locally, but there is also an export quota accounting for 36% of the landings in 2011. Landings which are not purchased by the main processing facilities are not recorded by the Department of Marine Resources (DMR).

Overview of the Harvest Strategy

Information

All decision-making must be based on reliable information about the fishery. In general, there are two sources of information on fisheries. Short-term studies offer snap-shots of the fishery status and can be used to answer specific research questions. Long-term monitoring is used to determine and respond to stock status as well as evaluate management actions. While both types of information gathering are important, long-term monitoring has proved the most difficult for the Bahamas to implement.

The key weaknesses in the data are that a significant proportion of the total catches are unrecorded and there is no overall reliable index of abundance (Table 1). Good fishery management requires either relatively low catches which are known to be at safe levels, or a better monitoring system which allows overfishing to be detected and tests whether management responses are working.

A recent initiative has requested electronic reports of catch and effort data purchased by processors to be submitted to the Department of Marine Resources (DMR). The programme has been operating for two years, but only one processor has consistently taken part so far. The data should be relatively complete and accurate, although the data have not been evaluated yet. This expands on the main source of catch data, which has been reported by processors since 1988. Other catch and effort data relies on trip interview sampling at landings sites. However, this sampling is not organised with any statistical rigor.

Interpretation of data is important and may well require careful interpretation. Measurement of catches will rely on conversion of weighed catch at different levels of processing. This needs to be standardized to a consistent form. The DMR has estimates to convert reported catches to the uncleaned meat weight, although in some cases these are based on small sample sizes (Table 2). It may therefore be useful to conduct more sampling at processors to ensure consistent meat weights are reported.

Stock structure is uncertain, but a working hypothesis could be adopted for sub-stocks based on bank and fishing areas. Any such working stock definitions have yet to be formalized. While ideally populations would be identified through scientific research, this is unlikely to be achieved in the short term. A better approach would be to use the available information, expert judgment from conch biologists and fishery managers and simulations to test the robustness of assumptions. The cost implications would also need to be considered as part of the decision since controls and monitoring will need to be applied independently to each stock.

Surveys cover relatively small areas, and have primarily been used to estimate spawning activity in protected areas and fishing grounds. There is no survey time series, but there has been one repeat survey. So far, no complete survey has been carried out across the conch stock areas, mainly due to cost and logistic difficulties. Most surveys have been conducted by local non-government organizations. The two non-government organisations (NGO) which have been particularly active in conch research are Community Conch (www.communityconch.org) and the Cape Eleuthera Institute, which are involved in both research and outreach programs.

Opportunities to collect new data, without a considerable increase in available resources, are limited (Table 3). Sustained data collection would most likely increase the reliance on fishers and processors to report accurate information. The compliance and co-operation of the fishing industry with providing data has been low. Recent initiatives suggest processors may be relied upon to provide more data which are accurate, but it is unlikely there will be any simple ways to improve data from fishers. Fishers resist Government's involvement mainly because they believe this would lead to unnecessary interference and greater costs.

Table 1 Available data that the DMR and NGOs possess

Current Available Data	Strengths and Weaknesses
Total Catch Data	The only catches that are recorded are those purchased by the processing facilities. Landings for subsistence, or those purchased by many small local restaurants and smaller commercial outlets, are not recorded. The scale of the unrecorded total catch is not known.
Trip Interviews Catch and Effort	Trip interviews have been carried out primarily in New Providence since 1988. These data are a sample of landings which record the estimated catch and effort (days fishing) for each trip. The interviews rely on co-operation
Processor Reports Catch and Effort	Since 2011, a new approach has been promoted to require processors to collect and report data from their purchases. These data cover all products purchased from fishers, including conch. Data are submitted in electronic form to the fisheries department and automatically loaded into a database. Only one processor has so far consistently provided data.
Size Composition Fisheries Sampling	Ehrhardt and Deleveaux (1999) collected size composition data from landings in Grand Bahama, New Providence and Abaco in 1997 and 1998. The DMR is not currently in possession of the data, but the information may provide a useful base line for future analyses. Some additional sporadic shell size sampling has been conducted in 2000, 2001, 2002, 2005, 2006 and 2009.
Mapping data	A GIS is currently being developed to hold fisheries spatial data, primarily from remote sensing for the spiny lobster assessment. Descriptive information is available of the main conch fishing grounds, but quantitative information (e.g. areas of conch habitat) is not available.
Survey data	A number of surveys have been carried out over a number of areas. These have covered relatively small proportion of the Bahama's bank area, but have recorded density and observations on spawning. The DMR is not currently in possession of the data.

Table 2 Conversion factors used in the Bahamas to adjust processed landings to live weight (excluding the shell) (Unpublished Data).

Description	Conversion Factor	% of Live Weight	Number of Observations
Skinned Conch	1.79	56	874
Conch Meat	2.60	38	53
Trimmings	7.16	14	53

Table 3: New information that might be collected for the purposes of stock assessment and management decision making

New Data	Purpose of Data	How it may be collected
Total Landings	Used to estimate total biomass and fishing mortality and assess the effectiveness of catch controls.	All commercial purchases can be recorded and reported to the DMR. Subsistence consumption can only be estimated from consumption or intercept surveys.
Processor Size Composition	Long term monitoring of size composition can be used to monitor fishing mortality trends or estimate fishing mortality with a reliable growth model.	There are no commercial size composition categories, so specific data collection activities at the processing facility are most likely required. Simple mean weight of 100% processed product could from frozen bag weight and number of pieces. Unprocessed meat would be required for accurate measures by DMR staff based at processing facility.
Fishery Independent Abundance Surveys	Obtain an independent abundance index or absolute measure of abundance. Set total catch quotas as a proportion of the estimated biomass. Locate areas for stock structure or special protection.	Surveys will need to be organised to cover conch population areas. This would require suitable vessels and divers (fishers and biologists) in suitable numbers for the areas to be covered. Surveys are likely to be expensive, but costs can be reduced by careful survey design and reducing the frequency of surveys.

Assessment and Analysis

Previous Assessments and Analyses

The last stock assessment based on size composition of the landings (Table 4; Ehrhardt and Deleveaux 1999) did not find evidence that the stock was overfished, although it was pointed out that fishing on immature conch made the stock more vulnerable to overfishing. More recent surveys (Stoner *et al.* 2009, 2011, 2012) failed to find sufficient spawning stock within the fished or protected survey areas to support recruitment. In addition, Stoner *et al*. (2012) question whether the current size limit (landings of conch with flared lip shell) is effective, given that considerable proportion of the catch would take place before maturity.

The Ehrhardt and Deleveaux (1999) stock assessment is now out of date. The more recent Stoner *et al.* (2009, 2011, 2012) surveys only provide partial coverage and a snap shot of current biomass levels, but nevertheless indicate a higher risk than suggested previously. The lack of a consistent approach and regular assessment is a concern for this fishery.

Table 4 Summary of analyses carried out to determine stock status

Analysis	Data Used	Management Advice
Ehrhardt and Deleveaux (1999)	Primarily collected size composition from landings.	The stock was not considered overfished. The main risk factor which was identified was the capture and landing of juveniles.
Stoner and Davis (2010)	The surveys conducted near Andros Island in late May and early June 2010 represented eight sites identified as historically important fishing grounds and comprised a total area of approximately 31 535 ha.	Average adult densities were very low (< 3 adults/ha) at six of the eight survey sites. Reproductive potential of the surveyed areas was estimated to be very low.
Stoner, Davis, and Brooker (2011) Stoner, Davis, and Brooker (2012)	Survey densities within fishing grounds and within protected areas near Exuma Cays and Lee Stocking Island.	Conch densities are decreasing in the surveyed commercially fished areas to levels that will not sustain the populations. Although the Park protects existing conch, there is not sufficient recruitment from outside the protected area to maintain populations within.
Stoner, Davis, and Brooker (2009)	A survey was conducted during June and July 2009 at more than 300 locations on the Berry Islands bank fishing grounds.	Given the low density of queen conch adults over most of the Berry Islands bank fishing grounds, relative youth of the adult population except in the area west of Rum Cay where adults were very small, low mating frequency, and apparent loss of historically significant juvenile populations, it seems likely that recruitment overfishing is occurring.
Stoner *et al*. (2012)	Size and maturity data collected from Exuma Cays, Bahamas.	50% maturity for the population was achieved at 26mm lip thickness for females and 24mm for males, higher than previous estimates. The authors concluded that the minimum size should be raised to reflect maturity.

New Analyses

There are a number of analyses that can be undertaken on the data currently being collected (Table 5), and fewer that would be able to be carried with new data collection (Table 6). For new analyses, improvements in the data may be required, and scientific review would ensure that the scientific advice is accurate and captures the uncertainty. Some preliminary analyses were carried out on the available data, to provide a better assessment of problems which would be encountered (Appendix A).

A preliminary analysis of the available catch and effort data using a simple biomass dynamics model indicates that there is a significant risk that the exploited biomass is overfished. This cannot be determined with much confidence because the data are not of good quality and significant information is missing. Catch and effort is predominantly taken from New Providence landings and a significant proportion of the total catches are not recorded.

It is likely that the catch and effort data, which starts in 1988, only covers a small proportion of the time the fishery has been operating. During the period 1988-2000 there is a clear increasing trend in CPUE (Fig. 1). This can only be interpreted in two ways: either the stock size has been increasing or catchability has been increasing. Catchability may increase due to, for example, improvements in gear or vessels, or expanding fishing grounds, but there is currently no information on these factors. If it is assumed that the stock size is increasing, then the catches must have been below the replacement yield during this period. Assuming the change in CPUE is caused by a change in abundance, the implication from the stock assessment is that the stock was overfished in 1988, and while there has been some recovery, continues to be overfished in 2012 at the end of the time series.

The Bahamas catch per boat day is considerably less than the Turks and Caicos Islands, which should be a comparable fishery. The Turks and Caicos reported catches in excess of 400 lb/day, compared to the Bahamas' 150 lb/day, although Turks and Caicos catch rates fell to 250 lb/day in 2010 and 2011 resulting in a big reduction in their export quota.

Therefore, however the change in CPUE might be interpreted, the implication is that the fishery is currently at high risk of overfishing. This may only apply to the exploited part of the population. The Bahamas area is very large and it may be that spawning biomass might exist which is relatively lightly exploited. However, there is no direct evidence of any such spawning stock and, in any case, there is considerable advantage to managing the exploited population more efficiently, both in conserving spawning stock and in raising catch rates (earnings) for fishers.

There is also some evidence from size measurements which have been taken over the years (Fig. 2). Samples from landed shells of lip thickness have been taken, mainly from landings in Andros and New Providence. However, a consistent sampling regime does not appear to have been rigorously applied, particularly between 2000-02 and 2005-09. While there has been a small negative trend in lip thickness within 2005-09, the change is small and little confidence can be placed in this result. One reason for decreasing lip thickness is increasing levels of exploitation and therefore increased risk of overfishing.

Depletion models try to detect local decreases in stock size over short periods. There is an opportunity to use this approach in detecting declines in catch rate during the lobster closed season when fishing for conch becomes more intense. However, a review of reliable catch rate data within closed season (Fig. 3) suggests that they do not decline consistently despite higher catches during this period. It may still be possible to use this approach, perhaps combined with fishery independent surveys, on specific fishing grounds and smaller areas. However, such depletions across the entire archipelago are not likely.

Table 5: Possible analyses that could be undertaken to offer scientific advice to management. Some preliminary analyses have been undertaken with available data to test whether these options are worth pursuing and what additional supporting information may be required.

New Analyses Using Current Data	Data Used	Preliminary Result	Possible Management Advice
Biomass dynamics model	Available annual catch and effort data	If the recent increasing trend in CPUE 1988-2000 implies increased abundance, the analysis implies the stock is overfished and probably has been for some decades. This may form the basis for precautionary advice even if the assessment is unlikely to be precise.	Catch limits applied to available catch data only (i.e. processor) An export limit alone may not be adequate. Limits would need to be applied so that alternative markets could not be developed (i.e. the catch would be reduced).

New Analyses Using Current Data	Data Used	Preliminary Result	Possible Management Advice
Beverton and Holt F estimate	Size composition samples and growth model	The method could work if a reliable growth model is available for the measures taken.	Various management measures could be employed to limit catch or fishing effort. Advice is unlikely to be precise, so precise measures would not be required.
Depletion models	Catch and effort data during lobster closed season	This approach is unlikely to work. There is no evidence of consistent depletion (Fig. 3).	The analyses might suggest suitable seasonal closures, and catch limits.

Table 6 Possible future approaches for analyses that provide management advice based on data and other information which may be realistically collected.

Future Analyses	Data Requirements	Likely Management Advice
Mean length monitoring (Gedamke and Hoenig 2006)	A time series of size composition data and a growth model.	Give guidance on whether adjustments to catches are required. May be invalidated if selectivity changes (e.g. minimum size or gear restrictions are changed or enforced).
Size and age structured stock assessment	Total Catch, size composition and catch/effort in time series. This model would require considerably more accurate data than are currently available.	Detailed guidance would be available on total landings weight and minimum size

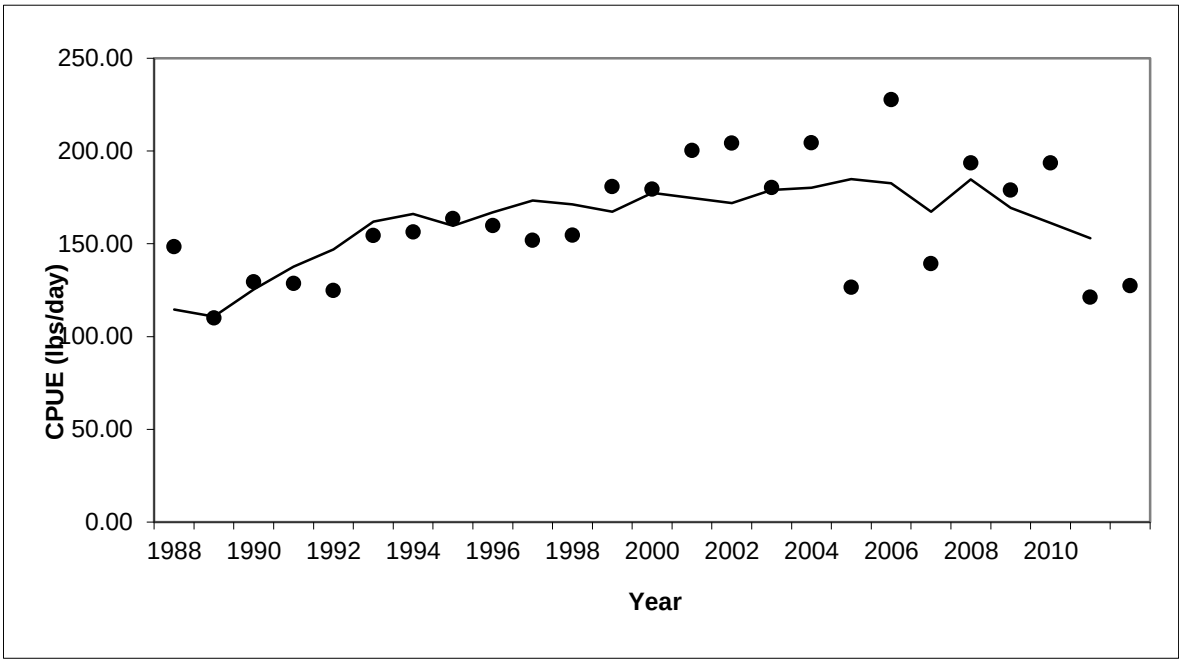

Figure 1 Preliminary analysis of the available catch and effort data based on a biomass dynamics model.

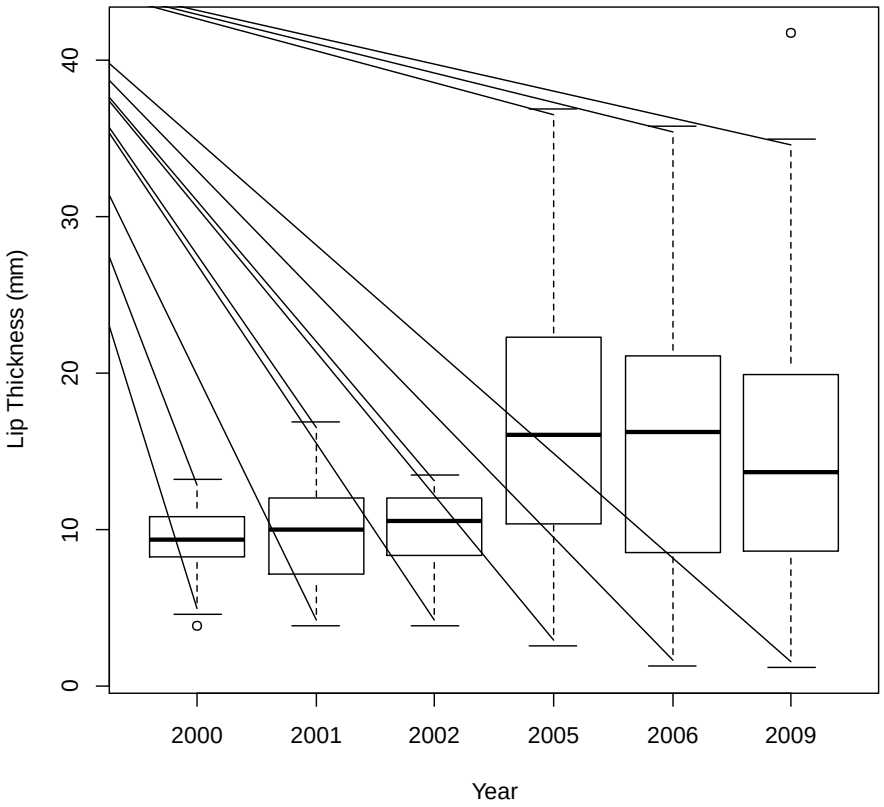

Figure 2 Box and whisker plots for mean lip thickness for the available years' sampled data (n=1606), showing median 50% quartiles and range of data sampled in each year by Department of Marine Resources.

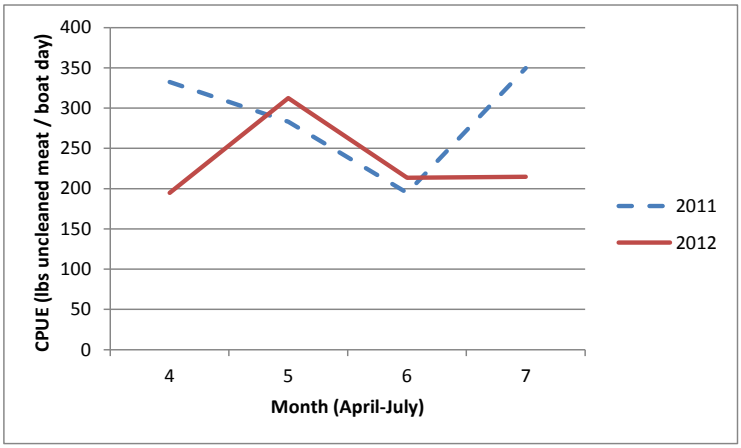

Figure 3 CPUE data reported directly by processors based on an initiative where purchase information is reported directly to DMR.

Management System

Fishery Objectives

The overall management goal for Bahamian fisheries is to ensure that Bahamian fisheries resources are utilized to provide the maximum socio-economic benefit for Bahamians without negatively impacting fishery stocks on which the fisheries are based. Only Bahamian citizens can take part in commercial fishing unless the individual is in possession of a spousal permit or a work permit that specifically allows fishing.

International conventions and agreements ratified by the Bahamas that are of direct relevance to the conch fishery include Convention on the International Trade in Endangered Species (CITES). CITES affects the management of the fishery through the Wildlife Conservation and Trade Act 2004. In addition, the recommendations promulgated by the CITES Animals Committee in Notification 2003/057 have resulted in greater emphasis being placed on the proper management of the fishery. This has resulted in improved documentation and control of queen conch export products as well as a greater sense of urgency with regards conducting stock assessments and enforcement activities.

The general objective is to ensure that conch is harvested in a sustainable manner while meeting local demand and only exporting excess product. While expansion of the fishery to supply the export market is desirable, this is only to be done when there is scientific support that exports will not diminish long-term availability on the local market, especially with regards to food security needs.

More generally, objectives for sustainability have not made operational because reference points and decision rules have not been defined. It is therefore not currently possible to evaluate whether the objectives are being met. Likewise, to meet the objective for exports, the amount required for the local market will need to be defined, which has not been done.

Management Measures and Regulations

Bahamian legislation affecting conch fisheries include the Fishery Resources (Jurisdiction and Conservation) Act 1977, the Wildlife Conservation and Trade Act 2004, and the Archipelagic Waters and Maritime Jurisdiction Act 1993. The Wildlife Conservation and Trade Act 2004 was enacted to further incorporate CITES into local law.

With regards to the Fishery Resources (Jurisdiction and Conservation) Act 1977 and the Wildlife Conservation and Trade Act, enforcement is the responsibility of the Department of Marine Resources, The Royal Bahamas Defence Force, The Royal Bahamas Police Force and The Customs Department. In addition, Agricultural officers are empowered to conduct enforcement according to The Wildlife Conservation and Trade Act 2004. The Department of Marine Resources is the scientific authority in relation to CITES whereas the Department of Agriculture is the Management Authority.

The fishery controls in the Bahamas include a size limit, closed areas, export quotas and gear restrictions (Table 7). With the exception of export quotas, it is not clear what the level of compliance with these regulations is. All management measures are static (fixed non-varying controls). The only control that has changed recently was an increase in the export quota, which was not based upon scientific advice.

The current size limit prohibits landing of conch without a flared lip. However, the majority of landings do not include the shell and whether a lip is flared or not flared is imprecise. It is believed that fishers have probably not targeted juveniles because the meat yield is too low, but if the stock becomes depleted, juveniles could become an increasing proportion of the catch, exacerbating the effect of overfishing. A possible strengthening of this control measure is to land the meat uncleaned or only partially cleaned, and to alter the regulation so that it applies to a measurable attribute of the landed product.

The gear restrictions are not enforceable since there is no inspection at sea. There has been no evaluation of the effectiveness of these restrictions. No one has ever been prosecuted for using illegal gears.
The current closed areas do not appear to be effective in maintaining stock biomass at sustainable levels. An evaluation of a protected area in the Exuma Cays (Stoner *et al*. 2011) suggested that the current closed area is not effective in preserving spawning stock biomass.

Exports rely on processors reporting the quantity of meat exported. This is not independently enforced, but relies on co-operation from processors. It is monitored to an extent by customs.

Table 7 Current management controls which are being applied

Control	Strength/Weakness	Evaluation
Flared Lip	Cannot be enforced for most of the fishery. Definition of "flared lip" imprecise.	Size composition data suggests landings of juvenile conch remains high.
Closed Areas	Marine protected areas have been implemented, but they have not necessary all be marked yet. In general, unless regularly patrolled, they are difficult to enforce.	Surveys indicate no higher abundance within closed areas.
Export Quota	The export quota relies on voluntary compliance by processors. The quota has been increased without scientific justification.	None. Although exports are superficially checked, there is no system to report data back to the DMR.
Gear Restrictions: no scuba; hookah is only allowed between 30 and 60 feet. No compressed air is allowed 1st April-30th July.	The depth requirement cannot be enforced without at-sea inspections. Compliance is unknown.	None

Management Options

Harvest Strategy

In developing management options, it will be necessary to consider a plan to assess how they might be implemented. Various options have already been proposed in recent times (Table 8), but there is a gap between these aspirations and what has been achieved. While interim precautionary controls are justified, these do not provide a long-term solution. Furthermore, there has been an understandable tendency to react to concerns by proposing immediate precautionary management controls, but long term sustainability will depend upon developing a harvest strategy.

A harvest strategy consists of various linked components, which, taken together, ensure sustainable harvest. The three components are harvest control rule, which limits catches, the information which the rule uses, and the decision-making process which applies the rule.

To be effective, any controls must limit or reduce catches. It is not sufficient, for example, to rely on MPA in areas which are never fished, or to implement a minimum size below the current smallest size that is caught. The larger the reduction in catch, the safer the fishery will be.

All controls should be evaluated, which will require an appropriate monitoring system. It should be possible to detect if the control is not achieving its objectives. Without monitoring, it is possible to have

regulations and controls which cost resources to implement, but in reality are of little value to the fishery. It is arguable that any management action which cannot be evaluated is probably not worth implementing. It is also highly desirable that the impact of the control is forecast as far as possible before it is implemented. If this is not done, considerable time can be wasted discovering that a control is ineffective or is unacceptable to stakeholders, which could have been detected before implementation. Therefore, what might appear to be an urgent action might in reality delay an appropriate response and place the fishery at greater risk than a more considered approach.

Given the value and importance of Bahamas fisheries, more resources need to be made available to the DMR. Currently, some activities depend upon NGOs (notably surveys) and several activities necessary for good management are not being done (notably routine monitoring and enforcement). However, the DMR currently lacks the capacity, primarily trained staff, to collect and manage the information required for good fisheries management.

Table 8 Management interventions that could be used to reduce the exploitation rate on conch in the Bahamas

Management Intervention	Background	Issues	Monitoring
Expand marine protected areas (MPA) network	Current MPA do not cover significant conch biomass.	MPA will need to cover some fishing areas to be effective. It may be slow to get agreement on MPAs from stakeholders.	Spatial data will be required, including abundance surveys to ensure significant biomass is being protected.
Ban use of compressed air on vessels when landing conch	This would prevent fishing on parts of the population (mainly larger conch).	Similar to MPAs, but protection would be for more mature conch. This would reduce catches if enforced.	Needs monitoring and enforcement at landing points and at sea. Size and maturity composition data will be required for evaluation. It may be possible to require that processors also collect simple size composition data (e.g. mean meat weight).
Establish regulation banning landing of immature conch	Preventing the fishery landing immature conch attempts to ensure conch spawn at least once before they are caught as well as catch them at an optimal size.	It will be necessary to required conch are landed in the shell, uncleaned or partially cleaned dependent upon how maturity would be measured. It is not necessary for an exact maturity measure to get the desired result.	
Set processor quotas	Quotas should be set for each processor, including all local sales.	Export quotas themselves are not likely to be effective since they cover only a small proportion of the total catch. Processors would have to agree the quotas.	Processors should be required to submit purchase records (at the moment it is voluntary) as well as exports.

Management Intervention	Background	Issues	Monitoring
Closed season	A closed season 1st July-30th September would reduce fishing effort directed at conch and would harmonise with closed seasons of USVI, T&C, Jamaica and Belize.	This is likely to reduce fishing effort, but by how much is uncertain. The impact on livelihoods is unclear. It may also increase opportunities for illegal fishing during the closure.	A closed season would require effort and catch monitoring during the closure covering all fishing not just processors.
Export Tax	This would reduce the value of exporting to processors and price paid to fishers, protecting the stock as well as raising revenue for fisheries management.	Ideally a tax could be applied to all landings. However, taxes are unpopular and it is unlikely it would get much support from stakeholders.	This would require co-continued operation by processors to report exports as well as prices paid to fishers.

Decision-making Process

A management organisation is needed which can not only receive, comprehend and act on scientific advice, but can also guide research to ensure the science remains focused on providing the information required for good management. The Bahamas management system does not provide a clear link between scientific advice and management decisions. There are a number of decisions which will need to be taken that depend upon the biology of conch, but also have important implications for the costs and organization of management.

There are a number of options to achieving improvements in management organisation. However, it is usually best to build upon organisations which already exist.

There is no tradition for using fishing co-operatives in the Bahamas. Although these work well in some countries to negotiate and to apply fishery management initiatives, it will difficult to get this sort of system in place where there is no natural cultural predisposition to this form of organisation. There are, however, fisher organisations which might be used to provide individuals to represent the fisher's interests as stakeholders.

The most developed organisations are the processing sector and the non-government organisations NGOs, notably the Bahamas National Trust and Community Conch. The processors provide most data and are able to control fishing activity through their purchasing. The NGOs provide conservation and cultural perspective to the management, and are particularly important for education and outreach initiatives to fishers and the general public.

There is currently no standard process through which the various stakeholders (Government, fishing community, processors and environmental NGOs) can represent their views or contribute to decisions in a transparent way. A management working group has been set up to help manage the spiny lobster fishery that provides this process for that fishery. Assuming the lobster working group is successful, a similar process could be developed for conch. Because the stakeholders are broadly the same, it would make sense in this case to extend the spiny lobster working group terms of reference to include conch. Such a working group would take responsibility for developing and implementing a harvest strategy. This is necessary because effective management will require constant evaluation and adjustment, which in turn will require stakeholder involvement in decision-making.

One decision required is on the designation of management units or stocks. These would define the different areas which may need to be managed separately, usually because they are suspected as being different conch populations. Currently, while the fishery is dispersed among the Bahamas archipelago, fisheries monitoring is relatively centralized to New Providence. Therefore, it will be necessary to find methods to improve coverage of the monitoring and enforcement systems. Although strictly speaking management units should be defined based on stock biology, invariably management issues make a strong contribution to decisions.

Another important decision is to develop a harvest control rule for each management unit that will react to changes in stock status as they are detected. The decisions from the rule should be based on science, but rule itself should be developed to include other management issues. Clearly, having a group of managers, stakeholders and scientists in a working group should make the development of the rule easier.

Research is required to identify initiatives which not only achieve fishery objectives in theory, but can be enforced and would not cause unacceptable socio-economic costs. Specific enforcement problems that exist include restrictions on the harvesting of juveniles, use of compressors without a license, use of the air compressor at depths outside of the stipulated range and poaching by foreigners. Although a seasonal closure of the fishery might reduce overfishing risks, for example, a closed season during peak spawning would coincide with the spiny lobster fishery closed season, which could have an unacceptable impact on livelihoods of fishers.

Table 9 Activities and specific example outcomes for developing a harvest strategy for the Bahamian conch fishery

Task	Example Outcome
Formally adopt management principles and objectives which will allow scientific advice to be given and which will guide decision-making.	Maximum sustainable yield and precautionary approach adopted as main principles and objectives for fishery management.
Develop a process through which principles and policy objectives will be obtained.	Invest a management working group with appropriate powers to implement policy and undertake activities outlined below.
Define management units	Identify appropriate conch management areas based on fishing grounds, likely population areas and administration centres, taking into account cost implications.
Generate indicators of stock status	Develop reliable measures of conch total catch, CPUE and mean size.
Adopt clear target and limit reference points for indicators	Endorse MSY based reference points for indicators estimated from best scientific research available.
Consider future scientific research to inform management.	Develop a short to medium term scientific research plan necessary for good management.
Develop a harvest control rule with stakeholders	Design measures to maintain the stock at or above MSY and additional actions which would be taken to reduce harvest should the stock fall below the target level (a rebuilding plan).
The enforcement and monitoring need to devolve to the main landing sites or stock divisions.	Set up 2-3 offices away from New Providence with adequate resources to cover additional enforcement and monitoring activities.
Complete a management plan defining the management process being implemented.	Agree a fishery management plan containing current management systems, information on the stock and decision-making process to be implemented for 5 years before re-evaluation.

Information and Assessment

The basis for the decision-making is the information being collected, which is poor. Poor information increases uncertainty and makes it particularly hard to reach agreement on difficult decisions, such as those limiting catches.

Catch data are incomplete and are a very significant source of uncertainty. Most fisheries science methods require complete catch data for any precise estimate of stock status. Unfortunately there is significant local consumption of conch which cannot be estimated. Some additional sampling and reporting is required to improve catch estimates. One possible solution to estimate consumption is to license restaurants and other local outlets that buy conch and make reporting a condition of the license.

The available assessments of stock status are not conclusive, and it is unlikely any precise determination of stock status will be available for some time. There is, however, enough evidence to imply management action should be taken to reduce exploitation significantly in traditional fishing areas. This is required under the precautionary approach to fisheries management.

Nevertheless, a robust stock assessment would be useful to update the status determination of the current fished areas. This is likely to show that the fished areas have relatively low stock levels, and considerable benefits would be achieved if these stocks were allowed to recover somewhat. Important benefits could include higher sustainable catches and higher catch rates increasing earnings to fishers.

Recommendations

1. Implement precautionary controls to ensure overfishing does not occur and that rebuilds stocks in depleted areas.
2. Implement a decision-making process. This process would oversee development and implementation of the harvest strategy.
3. Develop a monitoring system that provides 1-3 indices that monitor stock status and can be used to evaluate management initiatives.
    a. Catch is an important indicator and total catch should be estimated if at all possible. Estimate current catch coverage and if necessary, expand the monitoring coverage.
    b. Sampling for catch and effort. Improve sampling to ensure a consistent and accurate CPUE measure can be calculated. These data might now be available from the processors, but the data they collect must still be evaluated.
    c. There is no time series of size composition. Size composition data are difficult to interpret due to uncertainty over the growth model for size measures which can be collected in practice. Collect routine size data may be obtained from landings at processor
4. Complete a robust stock assessment using the available data, including catch and effort, size composition and surveys where appropriate. Advice should be based both on the data analysis and on simulations of data and management approaches, with the objective that any advice should be precautionary and deal robustly with risks and assumptions. Information from the assessment should be sufficient to develop a harvest control rule.

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Appendix A to Annex 1. Preliminary Analyses

Introduction

The following preliminary analyses were carried out on data which had not been fully analysed or on data which was assembled as part of this study. The objective of these analyses is not to provide scientific advice to management, but test how useful these data are for this purpose. This has allowed more detailed recommendations to be made on future data collection and analyses.

Catch and Effort Data: Biomass Dynamics

A simple biomass dynamics model was fitted to the available catch and effort data using a Bayesian fitting method (CRFM 2006). The model requires four parameters: an initial stock status (B_1), unexploited stock size (B_∞), an intrinsic rate of increase (r) and catchability (q). The model was fitted in an Excel Spreadsheet making use of the statistical software (R). This is not intended to be a complete description of the analysis, but does illustrate some of the problems with the analysis, but also some of its uses in guiding management decisions.

The weaknesses in the data need to be considered in interpreting the results. All local landings that are not purchased by the main processors are not recorded. The catch and effort data were based on trip interviews and in most cases landings are estimated for all species including conch, not actually weighed. These data were prepared by selecting trips that met criteria that implied almost all effort was directed at catching conch and that detected errors in recorded data (unrealistic records). Trips were removed where conch was less than 75% of the recorded catch or where the catch per day of conch was less than 10lbs or greater than 1000lbs uncleaned meat weight.

Preliminary results suggest that the stock is overfished (Table A.1), with biomass less than the MSY level ($B_t < B_{MSY}$) and fishing mortality higher than the MSY level ($F_t > F_{MSY}$). However, the fit has some problems, with evidence of changing variance in the CPUE (Fig. 1) and bias (Fig. A.1).

The underlying problem with the analysis is the interpretation of the data. Some catch data are missing and interpretation of the CPUE data requires scientific review. Trends from the nominal CPUE index reported previously (CRFM 2006) are very different to the trend from the cleaned data generated for this analysis (Fig. A.2).

Even assuming the data and their interpretation are broadly correct, there will still be considerable uncertainty in the assessment. The result will always indicate levels of risk associated with particular management actions. The most obvious way to reduce risk is to reduce catch, and in this case, at least in the short term, the only option would be to reduce exports. Currently exports make up approximately 300t of a total catch of 750t in 2011. Allowing the current catches to continue (Fig. A.3) would likely result in overfishing. Progressive reductions not only reduce this probability, but also, if the assessment assumptions are correct, should lead to increases in CPUE for the remaining fishery. Such information as this should be used as the basis for applying management controls to the fishery.

Table A.1 Parameter estimates

	Lower Percentile	Median	Upper Percentile
	0.05	**0.5**	**0.95**
r	0.22	0.38	0.60
B_∞	5071	8330	16908
Bcurrent	824	1942	7183
MSY (t)	606	745	1534
Current Yield		750	
Replacement Yield	368	558	693
B/BMSY	0.15	0.50	1.35
F/FMSY	0.74	1.86	2.99

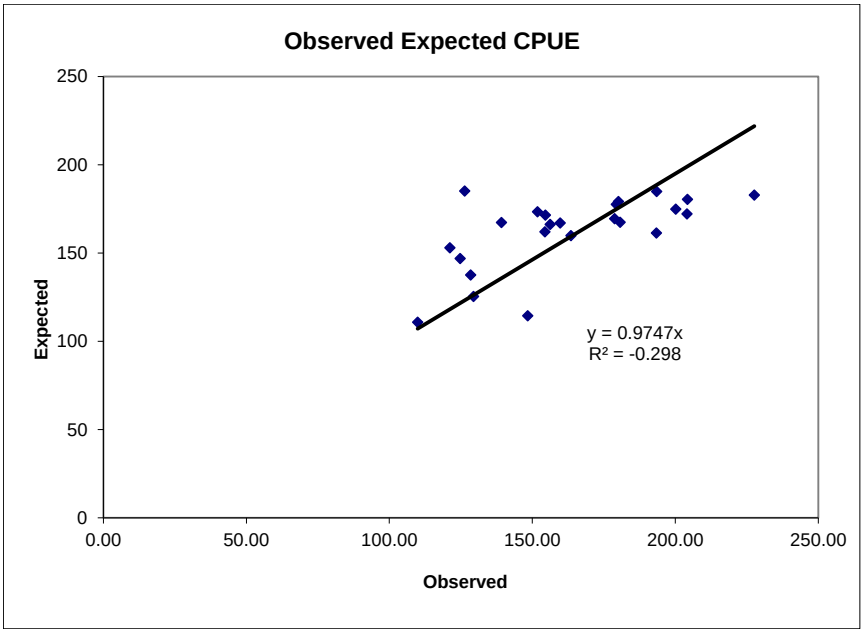

Figure A.1 Observed and expected CPUE to which the model is fitted to (see also Fig. 1).

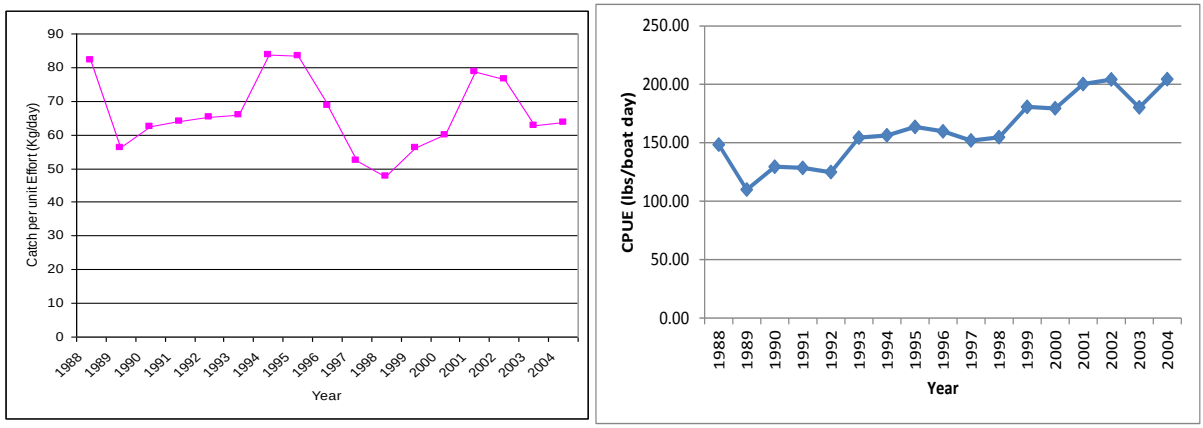

Figure A.2 CPUE index from CRFM (2006) (left) and current CPUE derived from the available data for this report (right) for the years 1988-2004.

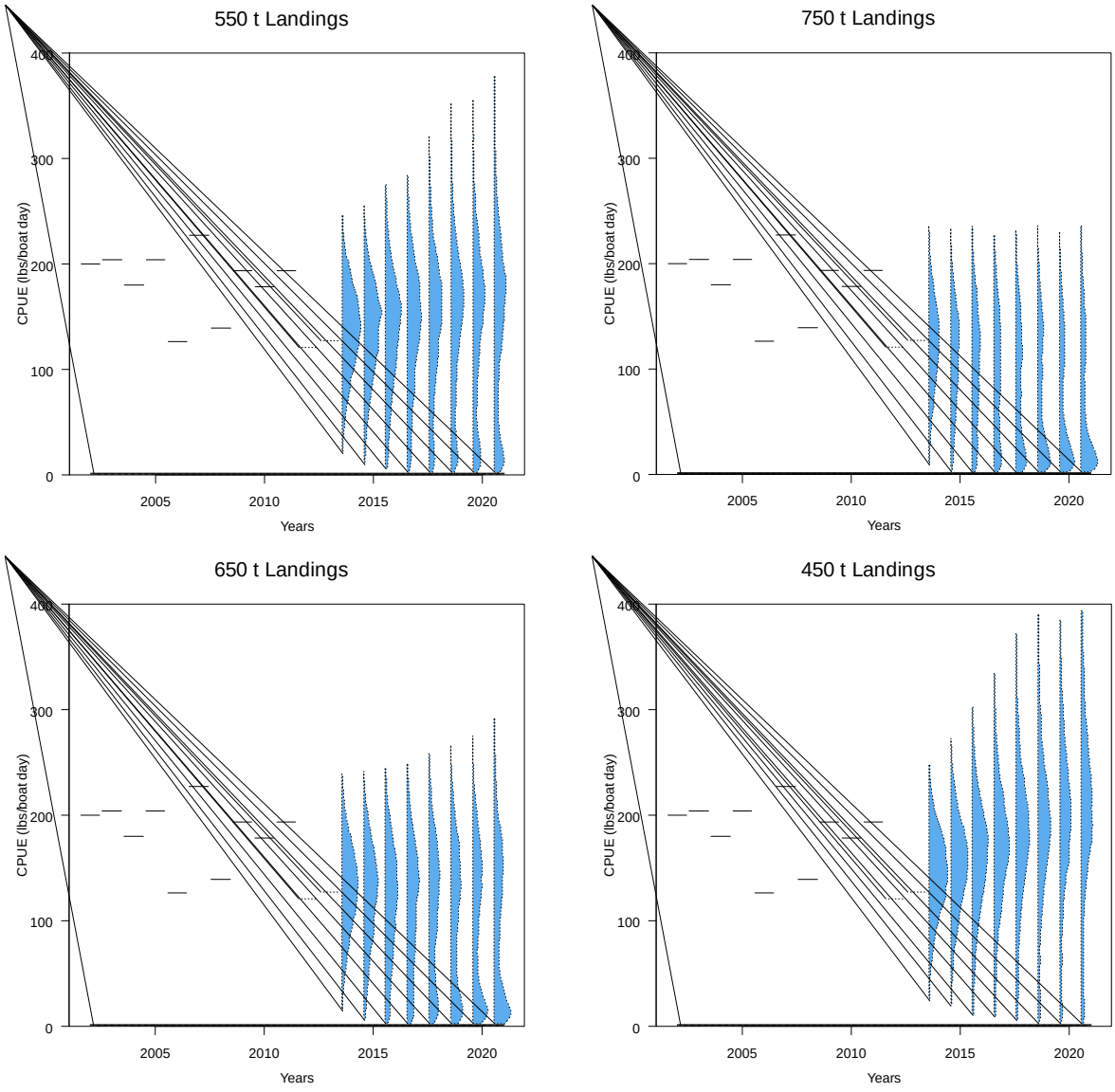

Figure A.3 Observed mean CPUE (horizontal lines) and probability density functions for the projection of different landings in tonnes (blue) based on a range of reductions in exports. 750t represents 2011 landings continuing, whereas 450t represents no exports. Flatter probabilities indicate greater uncertainty and probability mass close to the x-axis indicates the chance of stock collapse.

Lip Thickness Trend

Samples of lip thickness for landed conch (primarily in New Providence) have been taken in a number of years 2000-2009 (Fig. 2). The sample sizes taken in each year vary significantly, and the sampling that was carried out does not seem to have been consistent. The mean lip thickness for years 2000-2002 are significantly lower than for the period 2005-2009, but this is most likely due to different sampling rather than a significant change in size. There is a significant decrease in lip thickness 2005-2009 (Table A.2), but this is not conclusive evidence of change.

It is not clear that rigorous sampling methods were applied across this period and there is a two year gap between the last two observations. In addition, other assumptions of the model have probably not been met (such as independent observations), making interpretation of the data difficult. To provide positive guidance to managing this fishery, more rigorous data collection is required.

Table A.2 The tables show an analysis of variance and estimates for the year effect of a simple linear model of lip thickness. It is likely that some fundamental assumptions in the ANOVA do not hold for this analysis and therefore these results should not be relied upon.

	Degrees of Freedom	**Sum of Squares**	**Mean Square**	**F value**	**Pr(>F)**
Year	2	1579	789.5	14.651	5.02E-07
Residuals	1441	77649	53.89		

	Estimate	Std. Error	t value	Pr(>|t|)
Base Year (2005)	16.65	0.333	49.988	< 2.00 E-16
2006	-1.179	0.524	-2.249	2.47 E-02
2009	-2.394	0.443	-5.4	7.77 E-08

Appendix B to Annex 1. List of people interviewed

Note that the number of stakeholders met was lower than originally intended because the visit was unexpectedly shortened. Information was obtained indirectly from other stakeholders such as The Nature Conservancy Programme.

Name	Organization	Position/Role
Michael Braynen	Department of Marine Resources	Director
Edison Deleveaux	Department of Marine Resources	Deputy Director
Lester Gittens	Department of Marine Resources	Fisheries Scientist
Jared Dillet	"Conchservation" initiative	Project Manager
Alan Stoner	Community Conch	Independent expert
Mia Isaacs	Bahamas Marine Exporters Association (BMEA)	Chairperson

Appendix C to Annex 1. Main Activities Conducted
The case study involved a trip to The Bahamas 26th February – 6th March 2013.

Date	Location	Main Activity
26 February	Arrive (KE1 and KE2)	Meet with DMR staff: Mr Michael Braynen
27 February	Fisheries Office East Bay Street, Nassau	Meeting with Lester Gittens Management Checklist and SICA development
28 February	Fisheries Office East Bay Street, Nassau	Meeting with Lester Gittens Management Checklist and SICA development
1 March	Fisheries Office East Bay Street, Nassau	Development of case study methodology Extracting data from catch and effort databases
2 March	Departure of KE2 Hotel	Initiating report
3 March		
4 March	Fisheries Office East Bay Street, Nassau	Extracting data from catch and effort databases Meeting with Jared Dillet
5 March	Fisheries Office East Bay Street, Nassau	Reporting Meeting with Edison Deleveaux
6 March	Fisheries Office East Bay Street, Nassau Depart	Meeting with Alan Stoner (via Skype) Meeting with Mia Isaacs

Appendix D to Annex 1. The Bahamas - ACP Fish II Conch Fishery Information Checklist

The following notes are provided from interviews with the Department of Marine Resources staff, and information gained was used to inform the report. The notes are presented contain information that are the views of local staff and may include information beyond the scope of this study.

Stock Assessment and Management

Conch Management Issues	Commentary	Result
Life History	Has there been any local research on conch life history and ecology?	Al Stoner, Cape Eleuthera Institute
Stock Structure	Is the conch within your waters treated as a separate management unit, or is the stock shared with other countries, or are there sub-populations that should be managed separately within your waters? Is there significant IUU fishing?	Bahamian Sub population of adults within banks. Whether sub-pop within Great Bahama Bank Probably IUU from foreign but quantity unknown
Monitoring Data Types		
Abundance and Density Indices	Do you have an abundance index, for example based on CPUE or surveys?	CPUE Partial coverage by surveys
Catch Data	Are all catches recorded, or is there a significant catch which is unrecorded, such as subsistence and local landings?	Subsistence and local consumption catches are not recorded, exports are. Local consumption is very significant.
Effort Data	Are you able to estimate or record fishing effort? If so, how is it measured?	Effort (trip data) is sampled. Total effort is unknown. Effort measured as fishing days.
Vessels and gear	Do you have information on the vessels that catch conch and their gear, such as might be held in a vessel register or licensing system?	Under 20ft length vessels are not licenced. They are registered with the Port Department Greater than 20ft licenced Trip sampling (mainly New Providence) does record vessel, captain and gear information.
Management Strategy		
Target and limit reference points	Do you have target and limit reference points set for the conch stock(s)?	No
Harvest control rules	Do you use pre-defined decision rules to control the level of harvest?	No
Implementation of the harvest control rules	How do you control the level of harvest? How would the harvest be reduced if overfishing was detected?	An export quota Minimum size (flared lip) Opportunity cost of fishing conch No compressor during lobster closed season No plan to reduce harvest. Likely controls

		lower export quota, closed season, gear control…
Assessment and Analysis		
Assessment model used	Have you had a stock assessment for the conch stock(s)?	Surveys but no complete assessment Ehrhardt and Deleveaux's assessment Gittens and Hoenig (CRFM scientific meeting)
Robustness of the assessment to uncertainties and assumptions	If you have an assessment, have the uncertainties and assumptions documented and their implications assessed? Are these uncertainties reflected in management advice?	See assessment See surveys No coherent management advice due to poor/incomplete data
Stock status relative to reference points and projections of HCR	The main task of each assessment should be to define stock status and offer management advice to achieve the various objectives.	No HCR or reference points
Management Controls		
Area Closures	This is a decision for management whether to use no take zones or not. They need to be enforced, monitored and evaluated.	There are MPAs (general fishery reserves)
Seasonal closure	Commonly used, but probably needs to be harmonised across the region.	No seasonal closure
Effort Limit	Difficult to limit when effort monitoring is scarce and way to measure it is not known.	Fishers are belongers (excludes foreign commercial fishing)
Catch Limit	Need a catch documentation system and export limit for all countries. A limit on domestic catches may be difficult to implement.	There is an export limit
Sizes Limits	Shell length, lip thickness, meat weight (with processing level) may be sampled depending on the fishery and market. It needs to be shown that multiple size limits are compatible, can be enforced and that they work.	No landing unless there is a flared lip. But "flared lip" imprecisely defined.
Bag limits	Need to be shown it can be enforced and that it works.	Foreign recreational fishing
Other limits	Are any other limits or controls applied?	No

Management System

Conch Management Issues	Commentary	Result
Decision-making	Setting up the authorities may require legislation. An independent scientific authority needs to be designated with the necessary resources to conduct assessments. The management authority should include a transparent decision making mechanism.	Decisions are made by Minister/EXCO, based on advice from Fisheries Department No management working group for conch (is one for lobster) Decisions Gazetted but no reasoning given
Policy	Clear objectives stated in a management plan. Objectives should be compatible with CITES Appendix II. Precautionary approach should form part of the policy	There is a FMP, but conch policy short of specifics. This is of active interest at the moment through activities of NGOs.
Review	Independent reviews of the management plan and scientific assessments are highly desirable.	No formal review.
Research Plan	Potential yields and hence initial reference points will have to be established. Scientific research will be required to assess the unexploited state of the fishery. Various biological models of the species, such as growth and natural mortality rates, will be useful in refining management. There has been considerable research on conch. How and when it may be used once a basic system is in place should be reviewed.	In process of developing research plan for funding and developing staff activities.
Compliance	Fishers and fishing industry employees should be involved and aware of the management system as much as possible. Where fishers contravene the system, management needs to be able to show effective corrective actions, such as prosecutions and sanctions, have been applied. Socio-economic Incentives: Types of incentives for sustainable fishing include long term investment in the fishery, training and education, secure tenure and other co-management approaches.	Juveniles are landed, proportion unknown. IUU unknown but possibly significant MPAs probably complied with where clear markings Some MPAs await markings Export quota enforced

Ecological Impacts

Conch Management Issues	Commentary	Result
Habitat	Generally mapping of relevant habitats for this species is straightforward. If density surveys are to be used, area stratification based habitat and fishing ground is necessary. Any potential impacts on hard corals and seagrass should also be considered (e.g. from shell discards). Physical impacts of the gear should be negligible unless fishers are anchoring on coral reefs or discarding shells in inappropriate places.	Habitat map (broadscale) exists Main fishing areas mapped Some areas surveyed Low risk to vulnerable from conch fishing Shells built on middens, not put back in sea Possible decline in habitat could have a negative impact on conch
Ecosystem	There is predation information, but not enough for ecosystem models. Unless there is monitoring of several key species, this will be difficult to assess. Even where such monitoring takes place, relating changes specifically to conch fishing will be difficult. In general, the ecosystem may be considered not to be sensitive to conch abundance if overfishing is not occurring. The relative importance of conch in the trophic chain is yet to be determined. Main impacts are likely to be discarding of shells, discard of tissue after processing or multispecies effects. This would need to be monitored. Divers sometimes catch other species opportunistically. Finfish and lobster fishers also take conch opportunistically. Such catch needs to be monitored. It may be necessary to consider conch as part of a multispecies fishery. Some scientific assessment of acceptable impact on the ecosystem is required. This might follow standard environmental impact procedures.	No EAF for conch No modelling. Considerable information on biology and habitat, so ecological model and EAF possible

Annex 2: Belize Case Study

Background

Country Visit

The country visit was an essential element to conduct the national case study in Belize. The visit was conducted from March 6-8, 2013. The purpose of site visit was to evaluate the possibilities of enhancing scientific research to inform management decisions and to support a sustainable queen conch fishery. A number of activities were performed, including interviews with key scientists and managers and visits to the two main processing plants, where cooperative leaders, fishermen, and plant owners and managers were also interviewed. A list of the key people interviewed in provided in Appendix A and a summary of the activities conducted in Appendix B. A large part of the information was provided by staff of the Fisheries Department, Ministry of Agriculture and Fisheries. The results presented here summarize the data and reports analysed, as well as the perceptions of the stakeholders that participated in the interviews.

The main objective of the country visit was to obtain first-hand information about the queen conch fishery, the status of the stock, the data collection practices and the components of the management system. Emphasis was made on evaluating the existing (or necessary) methods to collect and analyse catch and effort data, as well as those to conduct biological surveys or fishery-independent monitoring activities.

The review of the management system included an analysis of the general legal framework, the fishery objectives, the harvest strategy, the research plan, and the monitoring, control and surveillance mechanisms used to ensure compliance with fishery regulations. A checklist of management information was completed during the interviews (Appendix C). Analysis of all of these elements unveiled the strengths and gaps in the system and the management needs for the fishery. These helped to formulate and discuss practical options to improve the scientific basis for queen conch fisheries management in Belize.

The findings from the site visit are summarized in this case study report.

Purpose of the Case Study

The objective of the case study is to improve the scientific approaches required to support sustainable management of queen conch (*Strombus gigas*) in Belize, and in particular, consider options for incorporating scientific information into effective management strategies. The case study will provide information necessary to consider harmonising management within the region which should lead to more effective support and cooperation among CARIFORUM countries.

Description of the Fishery

Queen conch is the second most important commercial fishery commodity in Belize after spiny lobster. In 2009, foreign exchange earnings from conch meat exports amounted to $7.6 million and 2,759 licensed fishermen participated in this fishery. In the last ten years the average conch production was 250 MT annually. Even though the conch fishery has been an open access fishery since its inception in the 1970s, the implementation of management measures have allowed the sustainability of the resource. Management regulations for conch include minimum size (shell length of 178 mm and market clean meat of 28g), closed season (1st July-September 30), and prohibition of SCUBA for harvest (Belize Fishery Department, 2006, 2010; CFMC/ CFRAMP, 1999).

The main fishing grounds for queen conch are located in the back reef areas and seagrass beds of the main barrier reef and in lagoon areas of offshore atolls. Harvest takes place in shallow waters at depths ranging between 5-75feet, from small canoes using exclusively free diving. Wooden sailing sloops measuring up to 30 feet are used as mother vessels. These are equipped with sails and auxiliary engines (15–40 HP); and can carry 8-11 canoes and a similar number of fishermen. The duration of the fishing trips can be 6 to

12 days. Fishermen sell conch meat directly to the fishing cooperatives that process, package and export the product mainly to the US (CFMC/ CFRAMP, 1999; BFD, 2006).

Since the development of the fishery in the 1970s, conch production has fluctuated with several peaks and troughs ranging from 111mt and 340mt (1977-2009). In 2009, conch production reached its highest level of 334 mt. In general, an increase in the number of fishermen (fishing effort) is followed by an increase in conch production volume, clearly evident from the year 2000 onwards (Figure 1) (BFD, 2010).

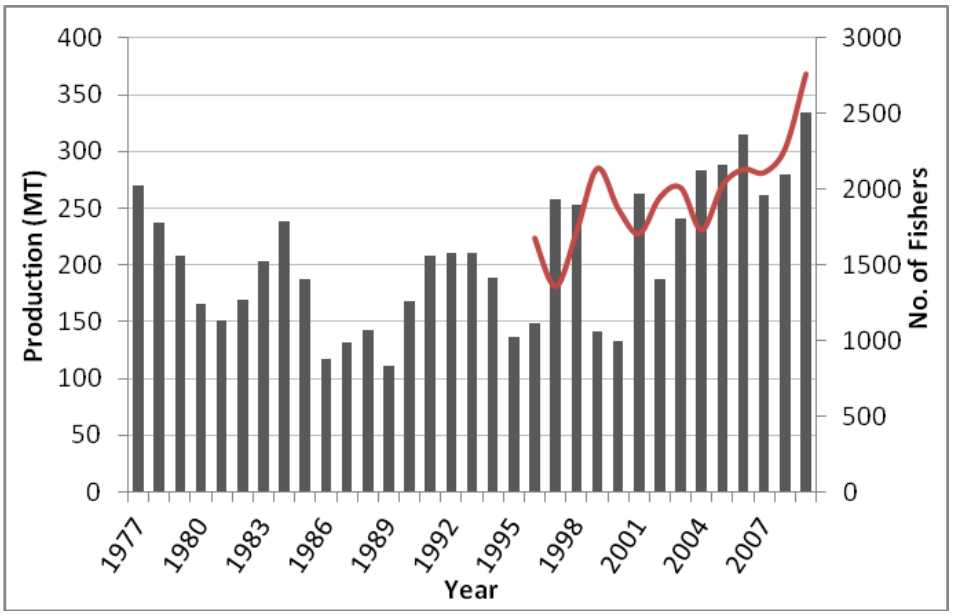

Figure 1. Historical conch production (in live weight, MT) and number of fishermen (Source: Belize Fishery Department, 2010).

In 2006, the Food and Agriculture Organization (FAO, 2007) reported that the queen conch stock of Belize was fully exploited. To comply with CITES recommendations the Fisheries Department carries out a national conch survey every two years to assess the natural populations of Belize. Field surveys have been carried out in 2003, 2004, 2006, and 2008, and 2010. The next one will be conducted in 2013. Results from these studies and stock assessments show high densities and signs of increasing abundance, but management measures are being implemented to prevent overfishing. Growth in conch production appears consistent with increased trends in abundance (FAO, 2007).

Overview of the Harvest Strategy

Information

This review concentrated on the data collection and analyses that are carried out routinely as part of the management and information system for the Queen Conch fishery at the Belize Fishery Department. The objective was to review the methodology used to assess the status of the stock, review if and how feedback is provided to the harvest strategy, and to identify the areas where there may be room for improvement.

The queen conch information routinely collected at the Fisheries Department includes fishery dependent data, sales and export data, export quality data, and fishery independent data from country-wide abundance surveys and surveys conducted within marine reserves. Other data that have been collected sporadically include catch and effort from trip interviews and biological data. Typical fishery data forms and a queen conch meat conversion information sheet used for data collection are given in Appendix D. Recently, the Managed Access Program also collects detailed catch and effort information from two pilot sites. These data types are included in Table 1, and details are provided in the sections that follow.

Table1. Available data at the Belize Fishery Department

Description of Data	Unit of Measurement	Years available	Sampling procedure
Landings at Cooperatives	Pounds of market clean conch meat (>3 oz individuals)	1977 - 2005	Monthly reports are gathered from 5 cooperatives.
Landings at Cooperatives	Pounds of fillet conch meat (>2.75 oz individuals)	2005 - present	Monthly reports are gathered from 2 main cooperatives.
Catch and effort data	Pounds of market clean conch (>3.0 oz) Days fished, number of fishers & fishing zone.	2000- 2005	Monthly amassed from each cooperative.
Production, local consumption, exports, value	Pounds produced, exported and consumed; US $	1977- present	Monthly reports at each cooperative
Export quality data	Random sample of conch exported (> 3.0 oz)	2005- present	Periodic inspection conducted at the 2 main cooperatives.
Abundance surveys (National and in MPAs)	Number of conchs in main fishing areas and MPAs Number, length, lip thickness, depth, and habitat are recorded	1996, 2003, 2004, 2006, 2008, 2010, 2012/2013	National surveys conducted every two years since 2003-2004. Surveys in MPAs every year, before and after the conch fishing season opens.
Biological data	Shell length, lip thickness, total weight, and meat weight by sex and maturity	1996, 1997, 1999	Single fishing zone
Managed Access Program	Catch and effort	2 years, since July 2011	Daily trip interviews in 2 pilot sites: Glovers Reef and Port of Honduras Marine Reserve
Marine Reserves: Conch and Lobster Monitoring Program (Abundance Surveys)	Number of conchs and length found in MPAs	2000 - 2012	Surveys in different zones of marine reserves; conducted before and after the conch fishing is opened.

* All the data collected has been digitized in an Excel spreadsheet

Catch and Effort Data

Total catches are monitored in Belize through the collection of landings information from the main fishing cooperatives/ processing plants where queen conch is landed. The main types of fishery-dependent data are:

1) a) Landings at cooperatives- Consists of monthly reports of catch and effort gathered from the two main fishing cooperatives: National and Northern. Cooperatives have a receipt system, with a receipt issued for each shipment of conch landed.
   The degree of processing of conch meat has changed over the years, and was defined in the Amended Regulations of 2005. There are three categories of conch meat:
   1. Unprocessed conch (>7½ oz individuals)
   2. Market clean (>3 oz.) - partially processed, organs removed.
   3. Conch fillet (>2¾ oz) - fully processed.

   Since 2003, cooperatives report fillet conch meat (>2.75 oz. individuals). Effort is reported in days fished, number of fishers, and fishing zone.
   b) Similar to (a) data consists of monthly reports from 5 cooperatives; landings were reported as pounds of market clean meat. Data from 1977 to 2005 are available.
2) Local sales and export data- Each cooperative has a production sheet per month, containing how much is produced, exported, consumed locally, and the value since 1977.

3) Export quality data- Periodic inspections are conducted at the two main cooperatives (National and Northern) to check compliance with the size regulation (>3.0 oz). A random sample of the conch exported is checked for the presence of undersized individuals. If the percentage of undersized exceeds 2%, another random case is sampled, if this percentage persists, a fine of $10,000 is imposed.

4) Trip interviews- Catch and effort data was collected in year 2000 and sporadically after that. This is not a routine sampling program of the FD.

5) Fishery data from the Managed Access program within Marine Reserves.

The majority of the conch landings are recorded, as most of the conch harvested in Belize is sold to the fishing cooperatives. Only a minute fraction (< 1%) goes unrecorded because there are a small number of independent fishermen and unlicensed fishers that sell conch directly to the local markets, restaurants and hotels. This information is difficult to gather and is not reported in the statistical records held at the FD. However, it is more beneficial for fishermen to sell their catch to cooperatives, and the information received from them is considered trustworthy.

In addition, all of the conch landed goes through Belize City. The two main cooperatives/ processors report all the purchases and exports. Other facilities (Plascencia, Key Caulker, Punta Gorda) are more receiving centres (no processing, packaging or labelling), and they send the entire product to the two main processors.

A limitation of the data collected from cooperatives is the accuracy of the information. Often the purchase slips are not completely filled out or the information does not reflect an accurate interview. Prevalence of this situation could significantly affect the quality of the data.

A second limitation is that effort is recorded in days fished and number of fishermen. There is a problem in the estimation of the actual effort, since there is often over-reporting of catch and days fishing. Sometimes, the amount of catch does not match the number of fishermen that fished per day, which skews CPUE. Effort data need to be calibrated or corrected to provide better CPUE estimates. As a consequence, effort from cooperatives is not considered realistic and therefore the preliminary stock assessments that have been conducted with commercial catch and effort information may be biased and are not used for management advice. In summary, only total catches are estimated from cooperative data, but fishery-dependent assessments are not conducted regularly and do not inform management decisions.
Another problem in the conch fishery is the illegal catch from neighbouring countries, particularly Guatemala and Honduras. IUU is not believed to be significant, but it occurs. There is no available data on the extent of illegal harvest and trade in conch. This information is difficult to obtain since there are

few resources available for monitoring and surveillance of this activity and the total amount of conch harvested illegally is unknown and the product is sold outside of Belize.

Vessels and gears

There is a licensing system in Belize. The fishing license is general, for vessels fishing multiple species. The same vessels are used for conch, lobster and fish.

Abundance Surveys

In 1992, the Queen Conch was placed under the management of the Convention for International Trade of Endangered Species (CITES) of flora and fauna under Appendix II. As a result, the CITES Secretariat mandated various conch exporting countries to establish their conch stock status to prove sustainable exploitation. It is in compliance of such advice from CITES that the Fisheries Department carries out a national conch surveys every two years to assess the natural populations of Belize. Field surveys have been carried out in 2003, 2004, 2006, 2008 and 2010 (BFD, 2010).

Surveys are used to assess the distribution and abundance of queen conch in Marine Reserves and other fished areas in Belize. With this information, the maximum sustainable yield, the exploitable biomass and the annual catch quotas are estimated.

The surveys are conducted using line transects along the entire length of the Belize Barrier Reef, primarily in the main conch fishing grounds within and outside the eight marine reserves of Belize. A stratified sampling technique is used to gather the field data. Sampling occurs in the same locations every survey, placing transects perpendicular to the reef, and extended from the back reef to the 15 meter depth contour towards the mainland. This methodology was first implemented in 1996 (Appeldoorn and Rolke, 1996) to estimate abundance and potential yield. The data currently being collected includes: the number of conchs found along transects, shell length, lip thickness, depth and habitat description. Generally, only shallow habitats (<15m) are sampled (BFD, 2010); therefore, surveys do not cover the deep-water adult stock.

In the latest survey (2010), a total of 125 transects were done at 13 sampling stations. The national conch density was estimated at 332 conchs/ha. An Analysis of the length frequency showed that 79% of the conchs measured are sub-legal <178 mm). Direct estimates of density per transect/ area are extrapolated to the whole country. The estimated national conch biomass yielded 1854.5 metric tons (4,079,834 lbs) based on calculation of abundance by site. MSY was calculated at 462.3 metric tons (1,019,959 lbs) and the precautionary exploitable biomass (75% of MSY) at 346.7 metric tons (764,969 lbs) (BFD, 2010). Comparisons with previous surveys suggest that conch densities have increased significantly: 14.3 conchs/hectare (1996), 38.89 conchs/ha (2003), 43.95 conchs/ha (2004), 109.6 conchs/ha (2006), 88.3 conchs/ha (2008), and 332 conchs/ha (2010).
Surveys have also concluded that no-take areas and deep water areas have higher densities of conchs as compared to shallow fished areas. In addition, results from surveys have demonstrated that the marine reserves are effective management tools, considering that densities are significantly higher within reserves (FAO, 2007).

A major assumption of the harvest strategy is that the adult stock in deep waters is protected by the prohibition of SCUBA diving. Thus, only sub-adult conch in relatively shallow waters are harvested. The adult population, however, needs to be quantified.

Biological Sampling

Routine biological sampling of conch occurs in two ways:

1) Biological surveys include the collection of shell length and lip thickness.
2) Export quality data- Periodic inspections at the main cooperatives to check compliance with the size regulation (>3.0 oz). Bags are sampled randomly to check for the presence of undersized individuals. Only clean meat weights are taken.

Full biological monitoring of the conch fishery does not occur regularly. A morphometric study (measuring shell length, lip thickness, total weight, and meat weight) was conducted in a single fishing zone in 1996, 1997 and 1999. It is important to establish a routine biological sampling program, although it is difficult because the shells are discarded at sea, and only semi-processed meat reaches the landing facilities.

Data Management

The Belize Fishery Department manages and stores the catch, export, license and registration data, and abundance survey information in Microsoft Excel spread sheets and in Microsoft Access databases. Hard sheets are kept in a filing system, also at the BFD in Belize City. The office in Punta Gorda is in charge of enforcement, also collects and stores data and performs administrative duties. Purchase and export data from fishing cooperatives is stored at the processing facilities.

The database is inadequate for raw data storage and retrieval, a more automated system that is linked to data from processors is necessary. Currently, staff from the BFD retrieve the data manually from processors; it appears as a very inefficient and error-prone method to transfer information to the Department.

The strengths and weaknesses of the data available at the BFD are provided in Table 2. The new data that might be collected for the purposes of stock assessment and management decision making is described in Table 3. Recommendations to improve the data collection system in Belize are provided in the final section of the report.

Table 2. Available data possessed by Belize Fishery Department

Current Available Data	Strengths and Weaknesses
Total Catch Data	Total landings (1977-2012) are reported by the co-operatives, which handle all commercial catches. Subsistence fishing is not monitored, but subsistence catches are likely to be small compared to the commercial exports.
Co-operative Reports Catch and Effort	Fishing effort is routinely collected from fishers by the co-operatives and reported to Government. The data consist of days fished by vessel and fishing zone, but only exists for years 2000-2005. The effort data need to be calibrated, as the reported effort often does not correspond to a single trip or vessel, but to a group of fishermen that report their landings together.
Size Composition Fisheries Sampling	A random sample of exported conch meat weights is routinely taken and data exist for 2005-2012.
Mapping data	Extensive mapping data on the barrier reef and surrounding habitats are available in a GIS. This includes survey abundance information, but does not include quantitative information on fishing effort or catches.
Survey data	A number of surveys have been carried out since 1996 based on mapping information. These have been used to evaluate the harvest strategy. Marine reserves have also been monitoring conch and lobster, before opening and closing of the season.

Table 3 New information that might be collected or compiled for the purposes of stock assessment and management decision making

New Data	Purpose of Data	How it may be collected
Processor Size Composition	Long term monitoring of size composition can be used to monitor fishing mortality trends or estimate fishing mortality with a reliable growth model more frequently than fishery independent surveys.	There are no commercial size composition categories, so specific data collection activities at the processing facility are most likely required. Size composition of exports are already collected for enforcement purposes. Biological sampling would require measurement of conch before cleaning.
Processor Fishing Effort	Develop a fishery dependent index of abundance which can be reported more frequently and with lower costs than surveys.	Processors collect and report fishing effort from fishers when they land conch. Some effort has been made to introduce this in the past, but it has been discontinued.

Assessment and Analysis

Previous Analyses

Stock assessments are conducted biannually, as a result from national abundance surveys. These provide estimates of national conch density and density by zones, which are used directly to estimate total abundance, by extrapolating abundance by area to the total area. Total abundance is used to feed two forms of a Surplus production model: Fox and Schaefer, which provide maximum sustainable yield estimates. Precautionary harvest levels of 75% MSY are calculated and used as reference points to provide management advice. Also, the size/ age composition of the stock by location is analysed in every assessment, with a calculation of the abundance of each age category (4 classes of juveniles J1 to J4, legal size conchs, adult conchs with lip formed, adults >17.8 cm).

Uncertainties and assumptions are considered in the surplus production model assessments, by conducting sensitivity tests on the natural mortality estimate (assumed equal to the fishing mortality, M=F=0.5). Also, 95% confidence intervals are built around the MSY value. These uncertainties and assumptions are reflected in management advice, when decisions on the quotas are made. Quotas are calculated near the mean MSY values or lower confidence limits. A summary of the analyses carried out to determine stock status is provided in Table 4.

There is no formal harvest control rule in place. MSY is used as a reference point; it is a direct outcome of the stock assessment, under the major assumption that stock biomass is known. Thus, stock status is not assessed in the conventional way, thus conventional limit reference points are not used either. In this case (absolute) population abundance is measured directly and the references used to assess (relative) stock status are the trends in abundance, density and annual production. Before surveys and stock assessments were carried out regularly, the references used were fishing effort, annual production volumes, and shell length (FAO, 2007).

Note that the surveys show a significant increasing trend in abundance (Table 5). Catches have also increased recently, so it is not clear that increases in abundance are driven by the fishery. Alternative explanations include the possibility that the stock was overfished in 1996, or the abundance survey is subject to some bias.

Decision rules have not been formalized, but they have been tested indirectly to ensure that they work and are precautionary. This indirect method consists in doing surveys and assessments every two years, and setting annual TACs based on those results. If quotas were detrimental, they would affect the abundance

and catch in the following period. Thus, if quotas were too high, biomass and MSY would be affected. The precautionary approach is applied by using 75% of MSY and the lower confidence limits.

Table 4 Summary of analyses carried out to determine stock status.

Analysis	Data Used	Management Advice
Appeldoorn and Rolke (1996)	A transect survey stratified by area including the main fishing grounds and marine reserves, was carried out in 1996 to estimate conch density, overall abundance and size composition.	The survey was used to indicate MSY of between 417-425,000 pounds, so a catch limit should be set below this. Given the uncertainties, the report also indicated the importance of the marine reserves in protecting the stock.
BFD (2004)	A stratified transect survey was carried out in 2003 using the same method, updated from Appeldoorn and Rolke (1996).	Management recommendations were made on catch limits, extending marine reserves and increasing the minimum size, but precise figures are not given. MSY and MEY were estimated to be approximately 680-714,000 lbs and 449-471,000 lbs, compared to the yield at that time of 628,000 lbs. It was suggested to increase the minimum size, but a precise size limit was not specified.
Appeldoorn (2004)	A stratified samples including the main fishing grounds and marine reserves, was used to survey the conch population providing density and estimates of abundance and size composition in 2004. This repeats the previous survey methodology.	The survey was used to evaluate no-take zones and MPAs, which were found to contain higher densities with a greater proportion of larger individuals, concluding that management zones were beneficial.
Carcamo (2006)	A stratified survey was carried out in 2006 applying the previous survey methodologies.	The survey was used to estimate MSY 935-1,086,000 lbs and advise on the current exploitation rate. The report also indicated that a minimum lip thickness of 5mm should be applied.
Carcamo (2008)	A stratified survey was carried out in 2008 applying the previous survey methodologies.	The survey was used to estimate biomass and subsequently the MSY and MEY of between 920-1084,000lbs and 613,000lbs respectively compared to landings in the previous year of 575,000lbs. It was recommended to use these MSY estimates with additional precautionary reductions to set catch limits.
BFD (2010)	As in previous years, a survey was carried out covering fishing grounds and marine reserves to estimate stock size and distribution.	Potential yield estimates were obtained from the biomass estimate based on an assumed stock model as in previous surveys. The MSY was estimated to be 994-1019,000 lbs. These were used to advise on a precautionary catch limit of 705-823,000 pounds meat weight.

Table 5. Exploitable stock abundance estimates from fishery independent surveys

Reference	Year	Stock Size (lbs)	95% CI Range
Appeldoorn and Rolke (1996)	1996	845,240	587,000 – 1,406,000
BFD (2004)	2003	1,602,328	953,531 – 2,544,764
Carcamo (2006)	2006	3,565,518	2,383,452 –4,747,584
Carcamo (2008)	2008	3,650,952	2,223,753 – 5,078,150
BFD (2010)	2010	4,079,834	N/A

New Analyses

New analyses were not conducted for this review. The BFD is considering an age-structured production model assessment in the future. Also, stock assessments that use fishery-dependent information are currently being tested, but CPUE estimates are believed to be biased due to uncertain (and biased) effort records. Effort standardization is a priority of the BFD, although it may be a cumbersome task.

It may be useful to re-analyse the survey data with the available fishery data within a single stock assessment. For each survey, a separate independent assessment of potential yield has been made, which has not taken account of the time series nature of the data. Surveys are dependent on each other through stock dynamics and should if possible be analysed together.

The Fisheries Department has been collecting economic information, and there is interest in pursuing bio-economic modelling of the conch and lobster fisheries. The BFD is interested in assessing the human factor and designing the quota based on bio-economic indicators.

The possible analyses that could be undertaken to offer scientific advice to management are summarized in Table 6. In the longer term, analyses should consider incorporating the Ecosystem Approach explicitly within the harvest strategy. Recent initiatives in Belize with managed access in protected areas could form the basis for ecosystem management of these fisheries.

Table 6. Possible analyses that could be undertaken to offer scientific advice to management.

New Analyses Using Current Data	Data Used	Preliminary Result	Possible Management Advice
Biomass dynamics model	Available annual catch and survey data, as well as effort data if available	Abundance surveys have been analysed independently to obtain potential yield estimates. There is a time series of surveys and catches which would allow a dynamic model to be fitted. This would provide a better estimate of MSY, replacement yield and the uncertainty in the estimates.	Catch limits applied to the landings to co-operatives.
Size structured production model	Size composition with total catch and survey data	A size structured model could work if a reliable growth model is available.	Various management measures could be employed to limit catch or fishing effort. Advice is unlikely to be precise, so precise measures would not be required.

New Analyses Using Current Data	Data Used	Preliminary Result	Possible Management Advice
Depletion models	Catch and effort data from fishing experiments, which might require temporary opening and closures of areas preferably with transects and tagging	This approach would be suitable for the spatial management implemented by Belize, but would be as difficult to implement as complete surveys. It would allow fishery dependent and independent data to be linked more clearly.	The analyses might suggest some seasonal closures, and adjustments to marine reserves, as well as possible negative bias in surveys. The technique is also useful for involving fishers in decision-making.
Yield per recruit model	Catch, effort, yield, size at 1st capture (Tc)	A reliable growth model is needed. Aim is to find a fishing mortality level to achieve a level of yield for each conch recruited to the fishery. The yield can be adapted to convert to processed meat yield or value. Size selectivity can be addressed. In general estimates of current F and Tc (or a full selectivity function) are required. Initial size is easy to obtain, but F and selectivity can be difficult. Fishing effort is usually used as a proxy for Fishing mortality.	Optimum yield per recruit and optimum size at first capture
Bioeconomic models	Catch, effort, yield, indices of abundance, price per pound over time, costs	Could be performed once the biomass dynamic model has been tuned to all data available. The economic component can be added, with detailed economic data.	Sustainable economic yield can be calculated, and decisions can be based on bio-economic indicators or reference points. The quotas can be designed considering bio-economic variables.

Management System

Decision-making Process

The Belize Fishery Department is the government institution responsible for the management of the conch fishery. The Forestry Department is the CITES focal point. The CITES authority is comprised of officers from both Forestry and Fisheries Departments and other organizations. The Fisheries Department liaises very frequently with CITES authority regarding conch matters.

There are mechanisms in place for consultation with stakeholders. The Belize Fishery Department has traditionally maintained excellent communication with fishers and fishing cooperatives on all fisheries related matters. The consultation process is well established and works effectively. The Belize Fisheries Advisory Board (FAB) is a body of people who are either involved or have interests in the fisheries sector and is the principal advisor body to the Minister of Fisheries. The primary function of this body is to

review and consider all fisheries related matters and make recommendations to the Minister, who generally adheres to the recommendations of the FAB.
The Belize Fishery Department also holds regular meetings but can also call special meetings if required to discuss specific issues regarding the conch fishery. The Department has been able to maintain good communication and excellent working relationship with all five fishing cooperatives. Cooperative leaders and members value the continuous presence of fishery officers at processing plants and believe that inspections before the product is exported have helped enormously with compliance of the size regulation.

In addition, cooperatives feel involved in the decision-making process. They perceive themselves as "participatory managers of the resource"; they know that they can voice their opinions and that their opinions are heard. The BFD frequently carries out outreach and education campaigns to educate children and fishermen in good fishing practices and environmental issues. Coop leaders believe that fishermen need to be reminded of these issues every day, so education and capacity building must be a priority of the Department.

The scientific information gathered from field surveys is critical in the decision-making process. The conch catch quota is set on an annual basis by the Minister and shall not exceed 70% of the MSY, based on a Fisheries Regulation established in 2005. Also, the conch meat export quota is set on an annual basis by the Minister and shall not exceed 95% of the quota. A conch survey is carried every two years by the Belize Fishery Department to determine the status of the conch stock. The Minister establishes the conch catch and export quota based on the results obtained from these surveys (FAO, 2007).
The following steps are involved in this process:

1) The Fisheries Department has a technical meeting to discuss assessment results and propose recommendations.
2) The Minister is informed of these results and recommendations.
3) The FD holds a stakeholder meeting to inform the conch industry (cooperatives, management committees, and fishermen) of the assessment results and the proposed strategy. The annual quota is declared and distributed among coops.
4) Once the quota is discussed and agreed with all stakeholder groups, a memorandum of understanding (MOU) is signed by the Minister.

Fishery Objectives

In 2005, a National Plan of Action for the Management of Fishing Capacity (NPOA Fishing Capacity) was prepared with the assistance of the FAO and OSPESCA that focused on the management of the commercially important fisheries resources including the queen conch. Neither indicators nor reference points have been clearly articulated in the National Policy. The Plan has not been adopted yet, but it needs to be revisited and implemented.

A fairly comprehensive Fishery Management Plan for the Queen Conch Fishery of Belize was drafted as a result of the Regional Workshop for the Monitoring and Management of Queen Conch held in Jamaica in 2006 (FAO, 2007). The information to update this FMP is available, and the BFD is interested in finalizing this effort with some external advice. The general objectives are designed by the Ministry, with a vision statement from the Fisheries Department. Specific objectives for conch still need to be structured and documented.

The draft FMP of 2007 established as the main operational objective for the management of queen conch to reduce or maintain the current fishing effort to allow maximum utilization of the conch stock. The implementation of the FMP would seek to achieve the sustainable use of the resource to ensure a constant supply, maintain high biomass to produce high production volume and high economic benefits for the present and future generations of Belizean conch fishers (FAO, 2007).

Management Measures and Regulations

The National Agriculture and Food Policy Document 2002–2012 is the principal policy directive established by the Government of Belize in regards to agriculture and food issues. The national policy is directed at ensuring a sustainable supply of marine products, particularly lobster, conch and shrimp.

The Fisheries Act Chapter 210 and Chapter 210 Revised Edition 2000 and subsequent statutory instruments constitute the principal Fisheries Laws and Regulations for the management of the fisheries of Belize including the conch fishery. The specific conch fishery regulations establish a minimum shell length of 7 inches, a minimum weight of partially processed ("market clean") conch meat of 3 ounces, a minimum weight of fully processed (filleted) conch meat of 2.75 ounces, a closed season extending from July 1 to September 30 inclusive in any year, diced conch is prohibited and recently an annual catch quota (controls are summarized in Table 7). The same Fisheries Laws provide for the establishment of marine protected areas in which marine species are fully protected in conservation and preservation zones (FAO, 2007).

Belize is a signatory and has ratified the following international conventions and agreements:

1. 1 Convention for International Trade of Endangered Species (CITES) of flora and fauna.
2. Specially Protected Areas and Wildlife (SPAW) Protocol of the Cartagena Convention.
3. Belize is also a member of the Caribbean Regional Fisheries Mechanism (CRFM) and OSPESCA (Spanish acronym for Central American Organization for Fisheries and Aquaculture Sector).

Table 7 Current management controls which are being applied or proposed (Modified from Belize FMP in FAO, 2007)

Control	Years implemented	Description	Strengths/ Weaknesses
Catch quota (TAC)	2005-present	i) A TAC is established each year to maintain stock above the biomass of MSY. ii) The TAC varies depending on conch abundance resulting from field surveys and estimates of MSY.	Efficient, but problems with illegal catch. The annual TAC will vary according to bi-annual MSY estimates from conch surveys.
Minimum size/weight	1977 2005	Partially processed conch meat –3.0 oz. Fully processed conch meat (fillet)– 2.75 oz.	Need good morphometric relationships and analysis of maturity by size/weight No certainty that regulation effectively protects juveniles.
Gear specifications and restrictions	1977	No SCUBA allowed	Only pre-adults and juveniles can be reached by free diving. Spawning stock may be protected but harvesting a large proportion of immature conchs juveniles could result in growth overfishing.
Seasonal (time) closures	1977	1 July to 30 September	Occasional illegal fishing during closed season.
Protected areas	1987	First marine reserves established in 1987. Since then another 7 MR with a	Conch resource is protected in 8 marine reserves, of which 5 are under direct management

		total area of 150,839 ha have been established along the Belize barrier reef and in the atolls.	of the Belize Fishery Department. Marine reserves were not designed exclusively to protect conch, but survey results indicate higher density and abundance within reserves.
Diced conch meat	2005	Possession of diced conch meat is prohibited	This measure discourages fishers from harvesting undersized conch and selling on local market as legal conch.
Access control (e.g., limit number of licenses)	Proposed (2007)	A maximum of 2,000 licensed fishers would be allowed to participate in the conch fishery. This would also to satisfy fishers' requests.	This measure would cap effort, but there is no guarantee that more fishers would not enter the fishery illegally. Enforcement might be a weakness for this control.
Effort control (e.g.,number of boats, number of gears, days fishing)	Proposed (2007)	A maximum of 800 licensed boats would be allowed to participate in the conch fishery. This would also satisfy fisher's' requests.	This measure would cap effort, but there is no guarantee that more fishers/boats would not enter the fishery illegally. Enforcement might be a weakness for this control.

Enforcement

The Conservation Compliance Unit (CCU) is the law enforcement arm of the Belize Fishery Department. The CCU carries out routine inspections of boats and fishers at sea and at restaurants, hotels and other business establishments on land.

Conch exports are monitored by the Capture Fisheries Unit (CFU) of the BFD, with the support of the CCU. Inspections of all conch export shipments are carried out by randomly selecting from 5 to 10% of all master boxes (boxes containing 10 – 50 lbs of conch meat) and one 5 lb box is taken out from each master box for detailed inspection. The frozen conch is allowed to thaw in order to gather weight measurements of all conch pieces in each box. The weight measurements are loaded on an Excel sheet, processed and analysed.

The fishing cooperatives fully cooperate with the Fisheries Department. Conch shipments should not have more than 5 percent of partially processed conch weighing less than 3.0 ounces. So far, no conch shipment has ever been denied a CITES export certificate by the BFD but cooperatives are fully aware that if and whenever it happens an export certificate will be denied and the product will be confiscated and the cooperatives will be charged with possession of undersized conch meat.

A similar inspection protocol has been developed by the BFD for ground conch exports. Fishing cooperatives need to follow strict procedures before any conch fillet is ground in the processing plant. A fisheries officer is posted at the cooperatives during the entire grinding process to ensure full compliance with the minimum size regulation. No problems have been encountered so far.
The types of sanctions and penalties issued by the Magistrate Court in case of non-compliance with fisheries regulations include arrests, fines, confiscation of products, gear, equipment, and boats.
Possession of undersized conch meat could be fined BZD $20-$30 per conch (FAO, 2007).

Management Options

There are a number of recommendations to improve the management system of Belize. Only those that may be feasible (financially and logistically) in the near future, that are a priority to the Fisheries Department and the fishing cooperatives, and that were discussed during the site visit are included here. New management options as such were not developed for this case study, given that the management controls that are currently in place are adequate and are scientifically based and that the management system contains most of the elements required.

While some controls may require further testing to prove their efficiency, most management options available for queen conch have been implemented in Belize. The types of changes recommended are aimed at improving elements of the harvest strategy to make the management system more effective, such as reinforcing or restructuring the monitoring programs, modifying the experimental design of surveys, utilizing all the data available for the assessment of stock status, expanding the types of analyses performed, developing robust reference points and harvest control rules, reinforcing control and surveillance mechanisms, etc. A summary of the main recommendations is provided in Table 8, and other details are included at the end of this document.

Table 8. Recommendations to improve the management system and reduce the exploitation rate on conch in Belize

Management recommendation	**Background**	**Issues**	**Actions needed**
Database management at the coops	Catch and effort information is collected at the; fisheries officers have visit the plants and collect the data.	Too much time spent collecting and entering the data. Not effective and error prone. Microsoft Access is not adequate to store and manage data	The BFD needs to streamline the information, so the data is entered at the coops and it is available in real time at the BFD. A new database system would help monitor the fishery on a day-to-day basis
Effort standardization	Time series of effort needed for fishery-dependent analysis. Effort is not accurate, reported in catch per boat per day, with variable number of fishers.	Effort is biased and cannot be used to estimate CPUE or in stock assessments. There is a discrepancy in the catch per fisherman by day; the bias can be filtered by grouping names of fishermen by boat. Perhaps not possible for the whole time series, cumbersome process.	Standardizing effort may require transforming units to time fishing (days or hours fishing). Effort monitoring will need to be modified, with appropriate changes in the information requested in the catch reports.
Review of CITES recommendations	Surveys are conducted every two years to comply with "non-detriment findings" CITES has a recommendation to harvest 8% of estimated abundance.	Surveys are expensive. Other, less costly methods may be used to estimate abundance and assess stock status. "Non-detriment findings" require trends in abundance in relation to reference points, not necessarily estimated from surveys. 8% harvest recommendation does not work for Belize.	Absolute abundance of conch in shallow areas is now well known, can be used as fishery-independent index in more comprehensive assessments that incorporate catch and effort information. Instead of the 8% recommendation, Belize pursues a harvest level based on science and constant monitoring of the resource.
Review of the survey design	Surveys are conducted every two years; the exact same transects (200-500 m long) are laid at same locations; mainly at shallow depths (<15m).	High cost of surveys. Transects are long and replicates do not have full coverage of conch habitats. Original objective of surveys was compliance with the CITES regulation. Objectives of surveys need to be redefined. Only juvenile stock in shallow waters is assessed.	Redesign stratified random surveys with shorter transects and greater coverage of habitats, depths, and the entire conch stock, including deep-water adults. More sophisticated analyses of survey information could be performed, such as comparison of abundance and age structure among habitat and depth strata. This would help to better understand the distribution of the conch stock in fished and unfished areas, and to evaluate the effectiveness of marine reserves.

			Need to develop a technique to survey the adult conch population.
Formalize Fishery Management Plan	A FMP with many of the necessary elements was drafted in 2006 (FAO, 2007)	FMP not completed or formalized as a policy document. Needs updating with new information. The BFD requires external assistance to include all necessary elements. Does not include a harvest control rule.	Update information in FMP. Formalize assessment procedure and feedback mechanism between assessment results and management advice. Develop a formal harvest control rule to reduce catches when reference points exceed limits.
Develop robust reference points and harvest control rule	Currently ad hoc rule, catch not to exceed 75% of MSY	MSY is the reference point used to modulate catch (through quotas). It is calculated directly from surveys, under the assumption that absolute abundance is known. Major extrapolation of density by area is involved in the estimation of absolute abundance (and MSY).	Based on new and more comprehensive assessments, develop more robust target and limit reference points. Develop a formal control rule to reduce catch when limit reference points are exceeded.
Quota allocation	Quotas since 2005. Annual TAC is divided by cooperative and distributed over a 9-month period.	Coops control quota, but there are no individual member quotas yet (ITQs). Distribution of monthly quotas among members has difficulties, especially with growing number of boats.	The Coops require a system to equitably allocate quotas (i.e., based on historical production, time of membership, participation in monitoring programs, history of compliance, etc)

Harvest Strategy

In developing management options, it will be necessary to consider a plan to assess how they might be implemented. A harvest strategy consists of various linked components, which, taken together, ensure sustainable harvest. The three components are harvest control rule, which limits catches, the information which the rule uses, and the decision-making process which applies the rule. The management system of Belize includes some form of these main components, and the aspects examined in this review indicate that they are systematically linked, with feedback mechanisms between scientific research and management. Some elements of the harvest strategy, however, need to be restructured or redesigned.

To be effective, any controls must limit or reduce catches, and all controls should be evaluated with an appropriate monitoring system. It should be possible to detect if the control is not achieving its objectives. Without monitoring, it is possible to have regulations and controls which cost resources to implement, but in reality are of little value to the fishery.

As noted above, many of the elements and information required in a management system are present, such as monitoring of total catch, abundance surveys, basic biological research, analysis of data, and control and enforcement activities. Given the value and importance of Belize conch fishery, more resources need to be made available to the BFD, or resources may need to be shifted toward activities that require more attention. For example, in compliance with CITES, significant resources are expended in conducting surveys, and in replicating the exact same transects over the entire barrier reef. Perhaps the sampling design could be revisited to utilize stratified random sampling, with fewer and shorter transects, that and save human and financial resources.

Regular monitoring of the fishery also occurs, with routine collection and entry of fisheries-dependent data (catch and effort from processors, size-structure of the catch) that are, however, not fully used for assessment. A small investment could help to improve the quality of the data that is collected (for example, fishing effort), and to streamline the transfer of data from processors to the Fishery Department, which would save staff time and money, and would help reduce the probability of errors in the database.

Currently, there is an unofficial decision rule to control the level of harvest by increasing or lowering quotas depending on stock abundance, which is estimated directly from surveys. While total abundance is known from the extrapolation of local densities, the reference points to detect overfishing could also be improved. Currently, only MSY and trends in catch are used as indicators. It is important that the existing time series of catch and effort are is incorporated in the analyses. This would provide a better estimate of MSY, replacement yield and the uncertainty in the estimates. Not all the information being collected is formally incorporated in assessments or to provide management advice.

There are signs that the conch population in Belize is experiencing constant growth, and there are no signs of overfishing. The BFD believes that this is a result of the combination of management measures, compliance, and marine reserve presence. However, the adult population in deep waters needs to be characterized.

Clearly, there are only minor changes needed in the management system to make it more efficient and effective. There is adequate capacity and trained staff at the BFD, but resources are not sufficient to fully perform all their obligations and duties. Thus, some resources may need to be redirected to improve the overall management system, or new sources of funding need to be identified and obtained.

Decision-making Process

There are a few essential options to achieving improvements in management organisation in Belize:

1. **Stakeholder participation in management:** The consultation process needs to strengthen the participation of all stakeholders involved in the fishery.
   Non-governmental organizations work in Belize but no references were given during this review as to their level of involvement in fisheries management. It is important that they provide their

conservation perspective to management, that they become more involved in creating awareness in the fishing community, and that they support the Fisheries Department in capacity building, education and outreach activities.

The fishing community and other stakeholder groups such as universities, research groups, processors, and NGOs must be able to represent their views on management or contribute to decisions in a transparent way. Cooperatives have a solid structure and are consulted for most management decisions, however it is unclear if other stakeholders actively participate in the decision-making process.

2. **Education/ Capacity building:** The fishing cooperatives consider that outreach and education activities need to be constantly reinforced by the Fisheries Department, to constantly remind fishers of the importance of conservation of the environment and good fishing practices. In particular, outreach programs are needed to educate fishermen on the importance of quotas and to discuss and agree on equitable allocation solutions.

Information and Assessment

The basis for the decision-making is the information being collected. The available conch fishery information is generally good, in quantity and quality, although some monitoring programs may need to be redesigned to improve the information being collected. The deep water stock needs to be characterized. The assessment methods are adequate, but there is room for improvement, as outlined in Tables 6, 7, 8, where suggestions for new or improved methodologies are provided.

Specific Recommendations

Information

- Improve data collection from fishing cooperatives.

  - The data collected from cooperatives needs to be more accurate. Purchase slips need to be completely filled out and the data verified. Continuous presence from FD staff would help to supervise data entry.

  - Improve effort reporting to reflect the actual number of fishermen that harvested the reported amount of catch.

  - Calibrate or correct existing effort records, so CPUE can be properly estimated and used in assessments. Interviews could be held every 2months to group the fishermen by boat and estimate the catch by day by boat or by fishermen.
- Quantify illegal catch from neighbouring countries, as has been attempted before. Get catch data from Guatemala and Honduras in Belizean waters.
- Establish a routine biological sampling program, although it is difficult because the shells are discarded at sea, and only semi-processed meat reaches the landing facilities.
- The BFD needs assistance to streamline the data from processors.

Assessment

- Perform/ revise stock assessments using fishery-dependent information. Effort and CPUE have to be calibrated to a realistic scale; some preliminary analyses have been carried out with calibrated data.
- Alternative assessment methods could be used to provide better information on the status of the resource or performance of the fishery:

- An alternative assessment model is a Yield -Per-Recruit assessment. Yield per-recruit assessments focus on fishing mortality as the main indicator and control variable. In yield-per-recruit the aim is to find a fishing mortality level to achieve a particular level of yield for each conch recruited to the fishery. The yield can be adapted to convert to processed meat yield or value. This method allows size selectivity to be addressed. In general estimates of current fishing mortality and the size at first capture (or a full selectivity function) are required. Initial size is

easy to obtain, but generally fishing mortality and selectivity can be difficult. Fishing mortality is usually related to fishing effort (FAO, 2007).

- Another alternative is a biomass dynamic model, which would use the comprehensive data set including time series of survey abundances and catches. This would provide a better estimate of MSY, replacement yield and the uncertainty in the estimates.
- Abundance surveys do not cover the deep-water adult population. Surveys should be expanded to those areas, to have an estimate of the size of the breeding stock and of the potential reproductive capacity.
- Training in Bioeconomic Modeling is needed at the Belize Fishery Department. Trends in production and value of the conch resource need to be assessed.

Management

- Revisit and finalize the Fishery Management Plan for Queen Conch. The Belize Fishery Department is interested in continuing this effort with external advice. The general objectives are designed by the Ministry, with a vision statement from the Fisheries Department. Specific objectives still need to be structured and documented.
- Develop solutions for optimum quota allocation among cooperatives and within cooperative members. Individual member quotas have not been assigned yet, and difficulties are increasing with the growing number of boats harvesting conch.
- Patrolling and enforcement by the Fisheries Department needs to be strengthened. Additional resources are needed to improve monitoring, control, and surveillance mechanisms.
- The fishermen coops request more involvement in the management process. Even if the consultation process is generally good, fishermen would like to be part of all meetings where important decisions are made.
- The CITES criteria need to be redefined. Stopping exports is not an option for Belize, the fishery is an important generator of foreign exchange. Thus, the policy directive for the conch resource is maintaining the conch stocks healthy and viable to maintain or increase export levels.
- The BFD is interested in pursuing the MSC certification for the lobster and queen conch fisheries, and to have value added to the products.
- The fishery is moving closer towards limited entry, with rights for people that have traditional presence. Currently, the Managed Access program is conducting pilot studies in protected areas to test the advantages of this management method. More pilot studies are recommended, before implementation in all the marine reserves.

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Appendix A to Annex 2: List of people interviewed

The following people participated in the interviews and those marked with (*) provided most of the information on the fisheries management system and the current data collection in Belize.

Name	Organization	Position
Beverly Wade	Belize Fishery Department	Fisheries Administrator
**Ramon Carcamo	BFD	Fishery Biologist
*Adriel Castañeda	BFD	Managed Access Program
Kenneth Esquivel	BFD	Fisheries staff
Isaias Mahill	BFD	Marine Reserve Program
Robert Usher and cooperative members	Northern Fishermen Cooperative	Chairman and fishermen
Mr Elmer Rodriguez Mr. Fidel Castro Members	National Fishermen Cooperative	Chairman Vice-chairman Fishermen

Appendix B to Annex 2: Main Activities Conducted

The case study involved a trip to Belize March 5-9, 2013.

Date	Location	Main Activity
5 March	Arrive	
6 March	Belize Fishery Department	1. Meetings at Belize Fishery Dept- discuss data collections/ monitoring programs, methodologies, review data sheets, regulations. 2. Discussions of management controls and regulations: size limits, closures, managed access, protected areas. 3. Meeting with BFD Director- Ms. B. Wade- overview of policy, goals of the BFD- general and conch, projects.
7 March	Fishery Department	1. Education/ Outreach program event- presentations to middle-school students. 2. Presentation/ discussion of Marine Reserve Program, abundance surveys, stock assessment. 3. Discussion of gaps, needs, priorities, recommendations for queen conch management. 4. Meeting with ACP Fish II (S. Grant)-discussion of possibilities for revised workplan.
8 March	Fishery Department National and Northern Cooperatives/ Processing Plants	1. Meetings at BFD- discuss data collections/ monitoring programs, methodologies, review data sheets, regulations. 2. Discussions of management controls and regulations: size limits, closures, managed access, protected areas. 3. Meetings with cooperative leaders and fishermen at 2 main processing plants: Northern and National. 4. Interview R. Carcamo- Fishery checklist.
9 March	Depart	

Appendix C to Annex 2. BELIZE - ACP Fish II Conch Fishery Information Checklist.

The following notes are provided from interviews with the Fisheries Department staff, fishing cooperatives, processors, and fishermen. The information gained was used to inform the report. The notes presented contain information that are the views of local staff and include information beyond the scope of this study. (Interviews conducted March 6 to March 8, 2013).

Stock Assessment and Management

Conch Management Issues	Main Questions	Response
Life History	• Has there been any local research on conch life history and ecology?	-YES, last 5 years independent scientists, conch, lobster in Glovers- reproduction, growth (Charles Acosta-), PhD from England (Truelove)- Genetic analysis in the whole country, in the north, central, southern areas and Atolls. The analyses showed the distribution and where they come from. -WCS efforts at Glovers Reef. -WCS- stock assessment by Charles Acosta - In the 80's- M. Gongora and Azueta conducted conch hatchery studies - Strasdine- 1988- Growth parameters
Stock Structure	• Is the conch within your waters treated as a separate management unit, or is the stock shared with other countries, or are there sub-populations that should be managed separately?	-Shared with Mexico but hypothesis that also self-recruit. -Research at ECOSUR on the dynamics of conch at planktonic stage suggest that conch from Belize contribute to recruitment. -Self-recruitment- Truelove dissertation is trying to prove self-recruitment. Hypothesis of self-recruitment due to gyre system was proposed in 1980 for Lobster (by Galholt), also for Conch -Atolls (WCS research)- indicates that self-recruiting occurs in the atolls, due to a gyre circulation pattern. -Don't know if Mexico and Belize have separate stocks, but could be managed separately. Good for scientific knowledge, but for decision making shared stocks would complicate matters. -Quota system and reserves at the country level may be better management alternatives.
Monitoring Data Types	• Is the fishery routinely monitored and if so how is that carried out? • How are the data managed and stored?	- YES, there are 5 data collections, fishery-independent and dependent. - Managed and stored- Hard sheets in filing system and Excel- Database management needs to be improved. Stored at the BFD, Marine Reserves keep their data. - Another office in Punta Gorda that enforces regulations, collects data, and does administration.
Abundance and Density Indices	• Do you have an abundance index, for example based on CPUE or surveys?	- CPUE- Have the data but EFFORT is questionable, not realistic, need to CALIBRATE EFFORT to realistic scale. There are preliminary analyses. - Surveys- YES- direct estimation of density by transect-area and extrapolated to the whole country.

Catch Data	• Are all catches recorded, or is there a significant catch which is unrecorded, such as subsistence and local landings? • Are there any conch processors and do they report conch purchases or exports? • Is there significant IUU fishing?	- Significant catches are recorded, only a minute fraction (<1%) is unrecorded. More beneficial for fishermen to take catch to coops than to local market. The BFD trusts info from coops. - Poaching/ illegal catch- YES, from neighbouring countries. Belize has increased enforcement patrols, equipped in marine reserve network system- less poaching mow. Attempted to get info from Guatemala- not able to quantify it - Not significant IUU, but some exists. - YES, 2 conch processors, they report all purchases and exports. Others are more receiving centres (packaging, labelling) in Key Caulker, Plascencia, Punta Gorda. They only receive and send to main two processors. All conch comes to Belize City.
Effort Data	• Are you able to estimate or record fishing effort? If so, how is it measured?	- Recording effort- they report days fished and number of fishermen. Problem in estimation of the number of fishermen. They report larger quantity of catch and days, over-reporting; the catch reported doesn't match the number of fishermen fished per day, thus CPUE is skewed. - Need to calibrate effort a - correct it- Interviews every 2 months to group the fishermen by boat and estimate catch by day by boat or by fishermen.
Vessels and gear	• Do you have information on the vessels that catch conch and their gear, such as might be held in a vessel register or licensing system?	-Licensing system yes and vessels are used for conch, lobster and fish- multispecies. -License is general, does not include shark or cucumber.
Management Strategy	• How does the fishery management ensure the stock is not overfished?	-Regulations enforced annually- open and closed season, annual quota, marine reserves, managed access/ catch shares. -Biannual density surveys and stock assessment.
Target and limit reference points	• Do you have target and limit reference points set for the conch stock?	-MSY- 75% of MSY as the quota. -Estimate MSY first, they don't set targets before surveys and assessments.
Harvest control rules	• Do you use pre-defined decision rules to control the level of harvest?	-If production maximizes quantity and MSY is exceeded, then they close production. The BFD is conservative because they use the lower MSY limit. -Department policy- technical discussions and make decisions to come up with values to distribute the quota. - Also, the BFD looks at production and use lower limit the following year. Production information is the base- they know from coops the max and min production.
Implementation of the harvest control rules	• How do you control the level of harvest? • How would the harvest	-Seasonal quotas. Fishermen can contest, season closed if quota is met early. -Extended closed season if quota is exceeded. -Reaction to overfishing is that the BFD would extend

	be reduced if overfishing was detected?	the closed season: open or close the fishery when Science says it's overexploited. Minister would close for longer period to recuperate the stock, there is a specific clause in the Law- Minister has authority to open and close the season. -Last year (2012) quota was exhausted.
Assessment and Analysis	• What assessment and analyses are carried out on the available data (please provide any documents if possible)?	-Biannual assessments: estimate national density and density by zones, then density used to estimate direct biomass, biomass used in Surplus production model to estimate MSY, and MSY used as reference point.
Stock Assessment	• Have you had a stock assessment completed? • What method was used to assess the stock?	-Surplus production model- Fox and Schaefer (Garcia et al 1989) -Preliminary (fishery dependent)- CEDA tree (Tomlinson). - Choosing one or 2 models that work.
Robustness of the assessment to uncertainties and assumptions	• If you have an assessment, have the uncertainties and assumptions assessed? • Are these uncertainties reflected in management advice?	- Sensitivity tests on M and F. Assumption: F=M=0.5 is tested, but precautionary. - CIs 95% about the MSY value - Yes, uncertainties are reflected- considered in the decision of the quota- near the mean or lower limit-used for quota management
Stock status relative to reference points and projections of HCR	• Has the stock status been evaluated relative to reference points? • Have the decision rules been tested to ensure they work and are precautionary?	- No, maybe in the future with age structured models - MSY outcome of stock assessment. - Indirectly- every 2 years they do the assessment, if quotas were detrimental, they would affect the next abundance and catch. If quota were too high, MSY would be affected. Constant precautionary approach applied in using lower limits. Yes, decision rules are precautionary.
Management Controls	• For each management control that is applied, it would be useful to know whether their effectiveness has been evaluated.	
Area Closures	• Are any areas closed to fishing conch? • Have these areas, if any, been designed to protect part of the conch stock?	- Yes, Marine Reserves, they have an area that is a no-take zone- no extraction- to replenish marine reserve of the species. - Yes, everything was considered in the area within the no-take zone- conch, lobster, fish, sharks, etc. The office of Marine Reserves (Mr Isaias Mahill) assesses the resources (including conch) every year during the open and closed season.
Seasonal closure	• Are there closed seasons for conch and if so when are they applied?	- Yes, the conch fishery closes 1st of July to 30 September each year.

Effort Limit	• What are the limits on fishing effort (licencing, number of fishermen, alternative livelihoods)?	NO Managed Access only for 2 marine reserves- Port of Honduras and Glovers Reef, will probably be expanded to other marine reserves in 2013.
Catch Limit	• Is any sort of catch limit (quota) applied to conch?	National Quota is established annually.
Sizes Limits	• Is there a size limit (flared lip, shell length, lip thickness, meat weight)?	Yes, 3 oz market weight, 85% processed. Made it official (OSPESCA-FAO conversion factors) and it is enforced, it is a law. Shell- 7 inches length
Bag limits	• Is there a bag limit, and if so to which sector of the fishery does it apply (recreational, subsistence, commercial)?	NO, once you engage in fishing you must have a license. That enters the other 25% of the MSY not accounted for unreported, illegal catch that is considered when setting precautionary annual quotas.
Other limits	• Are any other limits or controls?	YES, fishermen are not allowed to sell diced conchs, size limits cannot be checked. Plants have to inform if they grind or dice without inspections.

Management System

Conch Management Issues	Main Questions	Response
Decision-making	• How are decisions on fishery management made? • Who is responsible for the different roles in decision-making (gathering information, giving scientific advice, making the final decision)? • Who is involved in the decision-making process (advisory bodies, stakeholder consultation, Ministerial structures)?	1) FD- technical meeting- discuss results and propose recommendations. 2) Minister is informed of these Conch technical recommendations 3) Call conch industry- coops and fishermen invited and tell them the strategy- declaring quota, distribution of quota, results of assessments- open to Management Committees of coops and fishermen. Discuss and once agreed on all sides, an MOU is signed- Minister signs declaration each year (Licel Aramilla). Then harvesting, monitoring and enforcement take place.
Policy	• Is there a policy document or fishery management plan, with clear objectives stated for the conch fishery? • Does government policy include the	NO- we have info, need to put it together- Need help here- to create FMP. Now- objectives designed by the ministry- vision statement of the department, more specific not articulated yet. Specific ones for conch need to be structured and documented.

	precautionary approach?	
Review	• Have there been any independent reviews of the management plan and/or scientific assessments?	- No management plan or eval of mgt plan, no eval of methodology- NO external review, but yes external advice from CRFM meetings (Medley), OSPESCA technical meetings Manuel Perez, Renaldi, Peruvian), . Appeldoorn to do the surveys, and analysis 1996, 2003-2004. - , BUT, yes, advice to design sampling design strategy for surveys, other assesements and analyses have been done - They want BIOECONOMIC
Research Plan	• Have you identified research needs necessary for the sustainable management of conch? • Is there a research plan that identifies research objectives, activities and funding?	YES, they have designed a research plan to identify sustainable indicators, incorporate biological, and socio-economic indicators. The BFD wants to use this information to do assessments and use Sustainable Indicators (Research Plan 2013).
Compliance	• Are fishers aware of the laws, regulations and sanctions? • To what degree do fishers, including foreign fishers, comply with fishery regulations and laws? • What enforcement is carried out? • Are there incentives to fish sustainably (e.g. long term investment in the fishery, training and education, security of tenure etc.)?	- YES, very aware. - Foreign- do not comply, there poachers. Locals- YES- 95-98% compliance, it's in their interest, they will make better money at coops than illegal market or Chinese market. - There is a parallel illegal market for undersized conchs, but it´s not big. - Enforcement- inspections, constant patrols, vessel inspections, also at fish markets and coops, and consumers- restaurants and hotels - Constant and sporadic inspections occur; this helps to detect irregularities. - Regular patrols at sea- once a week; Marine Reserves have their own patrols every day. Weekly- 20 agents in a national unit. - Also work with National coastguard- manpower is extended, also the police has authority to do inspections. Coast guard at sea. - Infractions, arrests, etc. CONSERVATION-COMPLIANCE UNIT (CCU)- have statistics, of how many arrested, quantity and the fine. Product is confiscated by the government- It's in the annual report. - Awareness- education program- schools, community, different institutions, NGOs help to educate public about the laws, EBM, functional use of marine reserves, pollution. - NO government subsidies.

Ecological impacts

Conch Management Issues	Main Questions	Response
Habitat	• Has conch habitat (depth contours, biotopes, etc.) been mapped? • Is data on habitat held on a GIS? • Are the main fishing areas mapped? • Are there thought to be any significant impacts on habitat associated with the conch fishery?	-They have info but not mapped with GIS because don't have the equipment- Surveys record density, size, habitat and depth- Need GIS software. -Not on GIS yet, but they have GPS coordinates, depth, density and habitat description. -Yes, the main fishing areas are mapped: the zones, atolls, marine reserves. -They have maps, not a system of GIS, need equipment and software. - No, the fishery is not believed to cause significant impacts on habitat, no anchor or buoys are used.
Ecosystem	• Is there any local research on the role of conch in the ecosystem? • Has there been any ecosystem modelling (e.g. Ecopath) with conch as a trophic component? • Is the conch fishery likely to be having any significant impact on the local ecosystem?	-Marine Reserves yes- do ecosystem approach - No modelling yet- If it helps, yes, they will do it. - No significant impact, has not been observed.

Appendix D to Annex 2: Belize Landing Forms and Standardized Meat Weight Information

Compiled Fisheries Data From Cooperative ____________________ Cooperative

Date: ____________________

Data Collectors: ____________________

Area	Gear	dye fish	Lob. Tail	Lob. Meat	Conch	Fillet Conch	Fish Fillet	Red Snap	Crabs

Belize Fisheries Department
Capture Fisheries Unit
Conch Survey 2008

Transect number ______________ Date ______________
Data Collector ______________ GPS coordinates
Area of Transect ______________
Start **End**
16Q ______________ 16Q ______________
UTM ______________ UTM ______________

Number	Shell Length (mm)	Lip Thickness (mm)	Distance (m)	Habitat	Depth (ft)	Comments

Belize Fisheries Department
Capture Fisheries Unit
Conch Export Inspection

Date

Time

Amount to be exported

Data Collectors

Coop' personell

Box checked

undersize
less than 3>2.8
less than 2.8 or equal to

signature

Co-operative

#	Box 1	Box 2	Box 3	Box 4	Box 5	Box 6	Box 7	Box 8	Box 9	Box 10
1										
2										
3										
4										
5										
6										
7										
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10										
11										
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21										

Catch Shares → Belize Managed Areas

BELIZE FISHERIES DEPARTMENT, CAPTURE FISHERIES UNIT
DAILY CATCH LOG FORMS

10301

Date (D/M/Y): / / 2011	Captain Name*:	
Captain Registration No.	Boat Name:	No. of Crew:

Fisherman Name	Fishery Product	Type of Fish	Fishing Method	Processed Category**	Quantity (No.)	Lbs.	Total Fishing Time (hrs)

*The captain is required to complete this form in duplicate daily according to Section 35, Subsection 2, Articles E and F. Captains are required to collect and submit the information from all crew members onboard a fishing vessel on this form.
**Processed Category: W=Whole; F=Fillet; T=Tail; HM=Head Meat; MC=Market Clean;

OFFICIAL USE ONLY

Officer Receiving Data: _____
Signature: _____
Date (D/M/Y): _____

MINISTRY OF FORESTRY, FISHERIES & SUSTAINABLE DEVELOPMENT

BELIZE FISHERIES DEPARTMENT

BELIZE FISHERIES EDUCATIONAL PROGRAMME
STANDARDIZED CONCH MEAT WEIGHTS

All fishermen are advised of the following conch terms and their definitions.

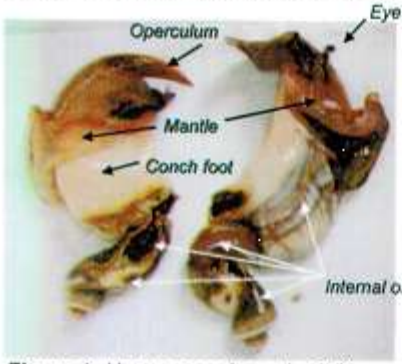

Figure 1. *Unprocessed conch - 7 ½ oz.*

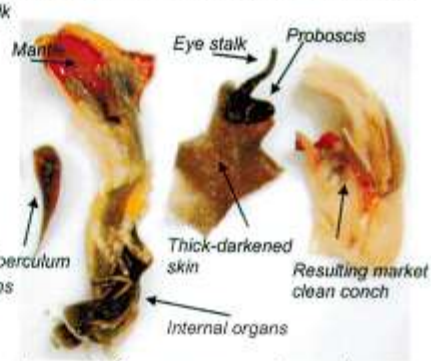

Figure 2. *Organs removed to produce a partially processed conch (market clean).*

Figure 3. *Partially processed conch (market clean) - 3.0 oz. (Dorsal view).*

Figure 4. *Partially processed conch - (market clean) - 3.0 oz. (Ventral view).*

Figure 5.
Fully processed conch (conch fillet) – 2 ¾ oz.

Definitions:

1. **Unprocessed conch** *means conch that has been removed from the shell with all organs attached and has a* **minimum weight** *of* **7 ½ ounces or 213 grams**.

2. **Partially processed conch** *(market clean conch) means conch that has been removed from the shell and from which the operculum, intestines, proboscis, head, eye stalks, ventral portion of mantle tissue and some thick-darkened skin on the foot have been removed and has a* **minimum weight** *of* **3 ounces or 85 grams**.

3. **Fully processed conch** *(conch fillet) means conch that has been removed from the shell and from which all body organs have been totally removed from the foot and has a* **minimum weight** *of* **2 ¾ ounces or 78 grams**.

Annex 3: Dominican Republic Case Study

Background

Country Visit

The country visit was an essential element to conduct the national case study in the Dominican Republic. The visit was conducted from March 9-16, 2013. The purpose of site visit was to evaluate the possibilities of enhancing scientific research to inform management decisions and to support a sustainable queen conch fishery. The main activity consisted in conducting interviews key scientists, managers, and data clerks at CODOPESCA (Dominican Council of Fisheries and Aquaculture). A list of the key people interviewed is provided in Appendix A, and a summary of the activities conducted in Appendix B. Appendices C and D provide the data forms typically used to record beach activity and landing and sales respectively. All the information was provided by staff of CODOPESCA. The results presented here summarize the perceptions of the people interviewed and the reports and data reviewed. New analyses on the existing data were not carried out.

The main objective of the site visit was to obtain first-hand information about the queen conch fishery, the status of the stock, the data collections and the components of the management system. Emphasis was made on evaluating the existing (or necessary) methods to collect and analyse catch and effort data, as well as those to conduct biological surveys or fishery-independent monitoring activities.

The review of the management system included the general legal framework, the fishery objectives, the harvest strategy, the research plan, and the monitoring, control and surveillance mechanisms used to ensure compliance with fishery regulations. A completed checklist of management information was created during the interviews (Appendix E). A SICA analysis was carried out to assess the main effects of the conch fishery from an ecosystem perspective, but the results were inconclusive and are not included here. Analysis of all of these elements unveiled the gaps in the system and the management needs for the fishery. These helped to formulate and discuss practical options to implement fishery improvement projects that would support a sustainable management framework in the Dominican Republic. The important background information and the findings from the site visit are summarized in this case study report.

Purpose of the Case Study

The objective of the case study is to improve the scientific approaches required to support sustainable management of queen conch (*Strombus gigas*) in the Dominican Republic, and in particular, consider options for incorporating scientific information into effective management strategies. The case study will provide information necessary to consider harmonising management within the region which should lead to more effective support and cooperation among CARIFORUM countries.

Description of the Fishery

The main fishery resources in the Dominican Republic (DR) are spiny lobster (*Panulirus argus*), queen conch ("Lambi", *Strombus gigas*), and a variety of demersal and pelagic fishes. Queen conch is the species with greatest volume of landings, making this species the most important fishery resource of the DR. In 2011, a total of 354,775 kg of queen conch were landed.

The queen conch stock in the Dominican Republic population is separated in at least three subpopulations or banks. First, the banks from the Atlantic and Caribbean are clearly divided, with influence from the Gulf current in the Atlantic and the Orinoco current in the Caribbean. The Caribbean is low in nutrients, while Atlantic side is characterized by high productivity, but the insular shelf is very narrow (less than 1 km wide). Jaragua Park is an important fishing area, but cannot be considered a bank. Parque del Este

(Eastern Park) can be considered as a third bank, where the stock has been decimated by sewage discharge, tourism, golf courses with high discharges of phosphates and sulphates into the ocean. Considering these differences, the Caribbean, Atlantic, and Parque del Este banks need to be analyzed separately, and eventually considered as separate management units.

In the south and southwest region the queen conch fishery is artisanal, with the main fishing areas in the region of Pedernales, around Beata Island, Jaragua National Park, and Alto Bello. Both, an artisanal and commercial fleets operate off of the north coast, with semi-industrial mother vessels that can carry an average of 13-14 and up to 30 dingy boats. A large volume of the conch harvested (illegally) in the Bahamas is landed in Puerto Plata, although fishing also occurs around Banco de la Plata.

Queen conch is captured in reef plains and seagrass beds, using free and hookah diving from small boats (10-20 ft long). With hooka gear, divers can go as deep as 200 feet deep to capture conch. Recently, trawl nets have also been introduced in Jaragua National Park to capture conch.

According to a census of the artisanal fishery conducted in 1990, the fleet comprised 62 boats between 7-25 m long and 247 auxiliary dingy boats. During that census, 81% of the fishermen were not associated, and 34% had a fishing license. Those numbers have remained fairly stable over the last decade, except in Parque del Este, where the fishery has declined dramatically.

In general, the queen conch fishery is very disorganized and has very limited control, monitoring, and enforcement of regulations. A high number of fishers, vessels, and compressors concentrate in a small area, causing the resource to decline in shallow areas, particularly in seagrass beds.

Since the 1980's, a number of studies have been conducted on the life history and status of queen conch populations in the DR. Some authors have noted the significant increase in conch landings since the 1968. Many of the population studies conducted in the 1990s and early 2000s, including CPUE analyses, and density/abundance surveys, were centered around Jaragua National Park (PNJ) and East National Park (PNE). In general, they concluded that the resource has been undergoing high fishing pressure for decades, and that further declines in abundance are expected to occur under increased effort levels (Mateo and Tejeda, 2008; FAO, 2009).

During the past 25 years, higher prices for queen conch were created by the export market, so the demand for queen conch increased, triggering an uncontrolled volume of landings in the whole Caribbean region, and the DR was no exception. For these reasons, in 1992 the species was placed in Appendix II of CITES, and later, in 2003, it was determined that the status of the resource was considered overexploited in the Dominican Republic, Haiti, and Honduras, forcing the closure of the export markets from these countries (Mateo and Tejeda, 2008; FAO, 2009). Before the moratorium, 80-85% of the conch production was destined to the export market. The market has dropped significantly since, and a number of facilities were closed. Many investments in the processing and fishing sectors became paralyzed with the moratorium. Ten years later, there is still pressure from the industry and economic and social interest to re-open the processing/export facilities and restore exports to the US. (Mateo, pers. com., 2013).

Overview of the Harvest Strategy

Information

All decision-making must be based on reliable information about the fishery. In general, there are two sources of information on fisheries. Short-term studies offer snap-shots of the fishery status and can be used to answer specific research questions. Long-term monitoring is used to determine and respond to stock status as well as evaluate management actions. Both, short and long term monitoring of the fishery

have been difficult to implement in the Dominican Republic, mainly because financial and human resources for research, monitoring, and control of the fishery are and have generally been very limited.

CODOPESCA has designed a program for the survey of statistical information, which is populated with data collected by one or two data collectors located at individual landing sites. This staff visit each site at least three times a week to record statistics on species, price, place, fishing gear, catch volume, fisherman, fishing vessel, time of fishing, etc. This data is sent from the different service stations to the Department of Capture Fisheries in Santo Domingo for digital processing and subsequent presentation and analysis (ACP Fish II, 2012).

The information described below focuses on the current monitoring system and on the data currently available at CODOPESCA.

Catch and Effort Data

The current fishery data collection system was formalized in 2008 to monitor all the fishing activities at every Administrative and Service Station at the national level. There are seven stations around the country, with one director in each region. Enumerators (data collectors) and fishery officers have been assigned to the main ports and beaches to record all the fishery activities. The data collection system uses three main instruments:

1. Beach Activity Log- collects daily information on the fishing units in a given landing site or port and period. The enumerator records the active, inactive, damaged vessels and those in repair, found during each day of observations. The fishing gears used by each vessel during that fishing day are recorded (Appendix C).
2. Landings Log- The enumerator interviews the fisherman at the beach or port; collects information about the gears used, the number of fishermen and the catch landed; and weighs the catch following the commercial classification in the area. The catch is classified in fish (of 1^{st}, 2^{nd}, 3^{rd}, 4^{th} class and others), crustaceans (lobster, shrimp, etc.), mollusks (Lambi, octopus, squid, clams, others) (Appendix D). Queen conch landings are generally *Strombus gigas*, except in Samaná where they are combined in the same category with other species, *S. costatus* and *S. pugilis*.
3. Analysis of Landings- Collects information on the species present in the sampled landings. This analysis also includes general data of the fishing trip (date, vessel number, captain, geographic location, depth, gears, time fishing, economic return, etc.), the organisms captured to the species level, the total number of species, the sex distribution and total weight.

These three components are linked and provide the basic information needed to determine the status of the stocks: fishing effort, catch per unit effort, and fishery production.

This format has been used since 2008 and aims at estimating production by species for any given period. Ideally, over time this data base is expected to become the basis for historical analysis of the fishery, to establish patterns of behavior of the stocks, recruitment periods, seasonal and spatial distribution of catches, and other parameters necessary for stock assessments (CODOPESCA Sistema Nacional de Levantamiento de Información Pesquera).

Export data is available at CODOPESCA. The fishery department issues import/export licenses and no-objection shipment certificates by date, product (shell meat Lambi), company. The amount, value, destination and exit port are recorded in the export logs. There were large volumes of conch exports prior to 2003. This raised suspicion by CITES, particularly because those volumes could not be justified by recorded catches in the DR. The catch volumes reported from international waters were also inconsistent with the volumes exported to the US. This led to the moratorium by CITES to export conch in 2003. Exports in the past ten years are minimal, with approximately 300 MT exported in 2012 to Vietnam, China, Hong Kong, and Curacao. Most conch is consumed locally or exported illegally.

In the 2005 report to CITES, the fishery department noted that based on CPUE analyses and survey results conducted in Parque Jaragua (Tejeda, 1995, 1998, and Posada and Mateo, 1998), the resource had not suffered permanent damage, and that it could recover under proper management, in particular, freezing fishing effort and protecting juveniles (Anon., 2005).

Before 2008, the data collected included volumes landed, based on beach reports and purchase/sale reports from processors, but there wasn´t a standardized format to collect the information, which complicated the estimation landings of queen conch and other species. Fish are still aggregated in groups in the landing forms, so only with consistent catch composition analysis, will it be possible to disaggregate commercial classes by location by species. In the case of queen conch landings, they are often aggregated with those of other mollusk species, so analysis of the catch composition is important to estimate the proportions landed by species.

Not all of the catches are recorded, so there are no estimates of total catch for any given species. First, the monitoring system only has 45-46% coverage because landings are recorded only on days when sampling occurs, and only at certain locations. Not all landing sites or beaches are monitored. Thus, a large volume of legal landings is not recorded. For example, Puerto Plata is one of the ports with the greatest fishing activity, however, it is estimated that the volume of unrecorded conch landed in Puerto Plata may be around the same levels as those estimated for the whole country.

Secondly, the proportion discarded or retained for subsistence is unknown. The commercial and subsistence fishery are mixed because the marginal benefits are minor; so the fishery is commercial but small scale and a proportion of the catch is often retained for self-consumption. Finally, there is an unknown but possibly significant volume of illegal landings by Dominican vessels from the Bahamas, Turks and Caicos and Jamaica. This product is often landed in Puerto Plata but sometimes commercialized at sea.

Unfortunately, there are no reliable data on fishing effort for any of the Dominican fisheries, including queen conch. Landing forms record the date, fishing area, depth, fishing gears and the time of departure and return. It is unclear if the time fishing by gear is recorded when multiple gears are used. Effort is estimated for the aggregated multi-specific landings, using the observed effort, the observed time and the effective fishing time. A total catch per unit effort by province is estimated on a monthly and annual basis. None of this information is specific for queen conch. Effort targeting queen conch can be disaggregated by sorting effort by gear. Compressor diving usually targets conch.

Vessels and gears

The data collection program also includes a licensing system for fishermen and vessels, and licenses for commercial exports and imports. Vessel and gear information are recorded in the beach landing logs. These contain the catch by fish category or species by boat by day by location. Licenses for commercial fishing are multi-specific; no special licence is required to harvest queen conch. Fishermen sell conch to dealers.

In 2012, a total of 3,470 documents were issued by CODOPESCA, including licenses (213 marketing licenses and 2,108 fishermen licenses) and permits (export, import), and no objection certificates for scientific research (CODOPESCA, 2012). There are also agreements for co-management and research with universities, CODOPESCA sponsors thesis research.

The most recent update of the census started in 2011, and so far approximately 3,600 vessels have been counted, although the actual estimate is of approximately 4,100-4,200 vessels. The current census is

comprehensive, includes the registry of vessels and information on fishing gears, type of vessel, mapping of areas fished, coding landing sites by region around the country, etc.

Abundance Surveys

Surveys are not conducted regularly in the Dominican Republic. Only a few research surveys have occurred in some of the main queen conch fishing areas in the Caribbean (Jaragua National Park), and the eastern end of the island (Eastern National Park), but the entire territorial waters have not been surveyed for queen conch. Most surveys have focused on juveniles; the distribution, density, and abundance of adults remain largely unknown.

There is no abundance information for the Atlantic coast in the north. Time series of density do not exist either, so isolated point estimates are difficult to interpret. In general, densities estimated in the late 1990's, particularly those of adults seem low in comparison to other areas. Information from conch surveys, however, has been used to some extent to guide management decisions, since other indicators of stock abundance are also scarce (eg., CPUE).

One survey was carried out in 1997 (Posada et al, 1998) to assess the distribution and abundance of queen conch in Jaragua National Park, at depths below 20 meters. The authors reported that 88.9% of the individuals were juveniles. The density and abundance estimates for juveniles were 53 conchs/ha and 1,076,169 conchs, respectively. At depths below 7 m, juvenile density was 74 conchs/ha and adult density, 4.6 conchs/ha. The areas surveyed were considered nursery grounds for queen conch.

Scientists affiliated with The Nature Conservancy conducted abundance surveys between 1998 and 2000 in Eastern National Park; densities were compared with those calculated by Posada et al (1998) (Table 1). The authors concluded that the resource was undergoing high fishing pressure.

Table 1. Average density of queen conch by hectare in Eastern National Park (PNE) and Jaragua National Park (PNJ) (Source: Mateo and Tejeda, 2008).

Juveniles (PNE, 1996)	283.0	Delgado (1998)
Adults (PNE, 1996)	4.5	Delgado (1998)
Juveniles (PNE, 1997)	22.5	Delgado (1998)
Adults (PNE, 1997)	1.6	Delgado (1998)
Juveniles (PNE)	14.4	Torres & Sullivan-Sealy (2000)
Adults (PNE)	0.6	Torres and Sullivan-Sealy (2000)
Juveniles (PNJ)	53.0	Posada et al. (1999)
Adults (PNJ)	0.6	Posada et al. (1999)

The last record of survey information for the DR is from Tewfik and Guzmán (2002), who compared average densities by transect in different areas of the Caribbean. In Jaragua National Park, densities ranged between 83 and 798 conchs per transect, and 144 conchs/ha in Barahona, suggesting a large variability among transect, even within the same location.

Biological Sampling

Routine biological sampling of conch does not occur in the Dominican Republic. The complex growth form of conch makes interpretation difficult. Shell size measurements, although more reliable, are difficult to obtain since the shells are discarded at sea.

Biological data has only been collected sporadically in the DR. Tejeda (1995) analyzed the size structure of the stock, and estimated morphometric relationships between shell length and weight, shell length and

operculum and volume and lip thickness. Later, the same author (Tejeda, 2005) found that 97% of the exploited stock were below the minimum legal length (<180 mm shell length) and that only 15% of the sampled conchs (N=841) had had shell lips formed with a thickness that could be considered adults or sexually mature.

In 2007, experts from the DR, Nicaragua, and Honduras were convened by FAO, CITES, and OSPESCA to take action on common queen conch fisheries issues. One important activity consisted in developing conversion factors for several processing grades of conch meat in each country, to improve protection of juvenile conchs. Sampling was conducted at two landing sites, Pedernales and Puerto Viejo, Azua, and the weight of each grade was determined per individual. The following measurements were taken: shell length, shell lip thickness, weight of edible meat, shell weight, total weight (meat and shell), sex, and maturity. Regression parameters for morphometric relationships and conversion factors resulting from this work are published in FAO (2009) and provided in Table 2.

Table 2 Conversion factors to nominal weight estimated for the Dominican Republic queen conch (FAO, 2009).

Processing grade	Conversion Factor	Number of Observations
Dirty	6.07	475
50 percent	8.42	475
85 percent	13.4	475
100 percent	15.9	

Data Management and Analysis

A systematic method is used to record and store the fisheries data collected by CODOPESCA. Fisheries officers and enumerators record the data on beach activity and port landings nationwide. All data are entered into the CODOPESCA database for subsequent analysis and evaluation.

The data collected as part of the national system is analyzed by technical staff of CODOPESCA in Santo Domingo and/or by the fisheries management stations in the provinces of Peravia and Barahona. Usually, data are entered in Excel and stored in Access. Unfortunately, due to the permanent shortage of resources faced by the institution, most fishery statistical summaries produced periodically with updated information are not published. However, the Ministry of Agriculture and Natural Resources has alleviated the lack of dissemination of information through the online publication of fishery reports (FAO, 2009).
Opportunities to collect new, more, or more detailed data, without a considerable increase in resources available, are limited (Table 3). More enumerators and trained biologists are needed around the island. Additional landing sites/ beaches/ ports need to be sampled. Data collection should not be interrupted on weekends or holidays. Logistic support is needed for all these activities, and would result in a significant increase in operation costs for CODOPESCA.

Alternatives to improve the information system are discussed in the management options section. The new data that might be collected for the purposes of stock assessment and management decision making is described in *Table 3*.

Table 2. Queen conch data availability at CODOPESCA.

Current Available Data	Strengths and Weaknesses
Total Catch Data	Annual conch landings are available since 1977. The characteristics and sources of these data have varied over time, as the fishery department has undergone many structural changes, working under different ministries. Data have been misplaced in the multiple transitions of the Department. The only catches that are recorded are recorded are those obtained from the landing and sales logs, obtained from enumerators at beaches and ports of landing. Catch for subsistence and discards are not recorded. Export data and annual summaries are available since the 1970's. IUU catch is probably high and unknown. Illegal catch from other countries is mostly landed in the northwest coast, particularly Puerto Plata.
Trip Interviews	Since 2008, catch and effort data are recorded on daily logs which contain the estimated catch per species per boat per day. Most variables are recorded reasonably well, including information about the location fished, the landing site, characteristics of the vessel and gear, the area fished, and the time spent fishing. However, being a multi-species fishery, only the total effort (using multiple gears to catch multiple species) is recorded. The effort spent on each target species is unknown. Trips targeting conch can be identified by the gear, but other species harvested by free diving or hookah can be present in the catch. Some interviews may include time by gear.
Biological Data	Biological data are not collected regularly. The most recent morphometric data was used to develop morphometric relationships and conversion factors for conch in the DR (FAO, 2009). A problem with biological sampling is that conchs are not landed in shells, so special arrangements have to be made with fishermen to be able to sample the shells.
Export Data	Available by date and species. Details not available for this review.
Survey data	Research papers by Delgado (1998), Posada et al (1999), Torres and Sullivan-Seally (2000). The authors may have shared the data with CODOPESCA. Time series of density information can help to understand trends in abundance over time.
Mapping	Jaragua and Eastern Parks have been mapped, including aerial photographs of queen conch habitats.

Table 2a. Details of the queen conch data available at the FD.

Data set	Description	Period	Strengths and Weaknesses
Daily Landings and Effort (Trip Interviews)	Daily catch logs available on hard copy and electronically since 2007.	2007-2013	Detailed data, with info about the vessel, fishing area, gear, trip, effort, catch by species. Fishery is not well covered by enumerators, trip interviews at fixed beaches/ports and on weekdays
Annual Landings	Total catch reported	1977-2013	Summary of total catch from all sources. Significant gaps in database from unreported catch, data losses, interruption in data collection.
Exports	Exports by species by date by processor	N/A	Exports are prohibited by CITES. Source of conchs exported is often unknown, perhaps IUU.

Table 3. Queen conch data which should be maintained (E=EXISTING) and collected (NEW data).

Data Source	Data Type	Purpose	How it may be collected
Market and processing plant purchase receipts (NEW)	Total landings.	Used to estimate total biomass and fishing mortality and assess the effectiveness of catch controls.	Daily/ weekly landing logs. All commercial purchases should be recorded and reported to CODOPESCA.
Processor exports (E)	Total exports (E)	Add to total landings.	Conch exports by month.
Daily landing logs (E/NEW).	Detailed catch and effort data by trip	Get CPUE index of abundance	Detailed catch and effort data within the trip, linked to purchase receipt to get accurate catch. Effort recording needs to be improved: effort allocated to each species per trip (eg., Conch effort in number of tanks or time in/out of dive).
Trip Interviews (E)	Catch and effort from trips	Estimate all catches from all beaches and ports. Alternative CPUE abundance index. Estimate discards.	Interview fishermen at landing sites. They are not likely to complete Logbooks. Expand this program to the whole country and sample all landing sites every day of the week (including weekends and holidays). Include information on discards or conch used for subsistence in interviews.
Biological sampling at landing sites (E/NEW)	Size, sex composition and maturity. Increase precision by stratified sampling[2].	Sex, maturity, size composition.	Sampling of shell size, weight, sex, and maturity at landing sites (need agreement with fishers to bring conch in the shell).
Size composition from markets and processors (NEW)	Increase precision by stratified sampling.	Mean individual weight of the landings.	Simple mean weight of 100% processed product could be estimated from frozen bag weight and number of pieces. A number of bags could be sampled randomly and periodically. Whenever possible, sampling individual weight of unprocessed meat would be required for accurate

[2] See Medley, 2008 for details of new data collections and stratified sampling design.

			measures .
Fishery Independent Abundance Surveys (E/ NEW)	Conch density and size structure by area and depth.	Obtain an independent abundance index or absolute measure of abundance. Set total catch quotas as a proportion of the estimated biomass. Locate areas for stock structure or special protection.	Surveys will need to be organised to cover conch habitats around the country. This would require suitable vessels and divers (fishers and biologists) in suitable numbers for the areas to be covered. Surveys are likely to be expensive and need to be replicated periodically. Only juvenile density has been studied; new surveys need to focus on searching for adults in deeper areas.
Mapping (E/NEW)	Conch habitats and fishing areas around the DR	Map conch distribution and locate main fishing grounds.	Transect surveys and aerial photography.

Assessment and Analysis

Previous Analyses

The Capture Fishery Department regularly summarizes the volumes landed by resource category, but being a multi-specific fishery, analysis of each species is very difficult. Tables of catches, estimated (total) effort, and overall CPUE are produced regularly for the annual statistical reports of CODOPESCA. Queen conch landings are reported as a different category, which facilitates summaries. Conch landings, even if with some fluctuations and gaps, are available since 1977 (Figure 1).

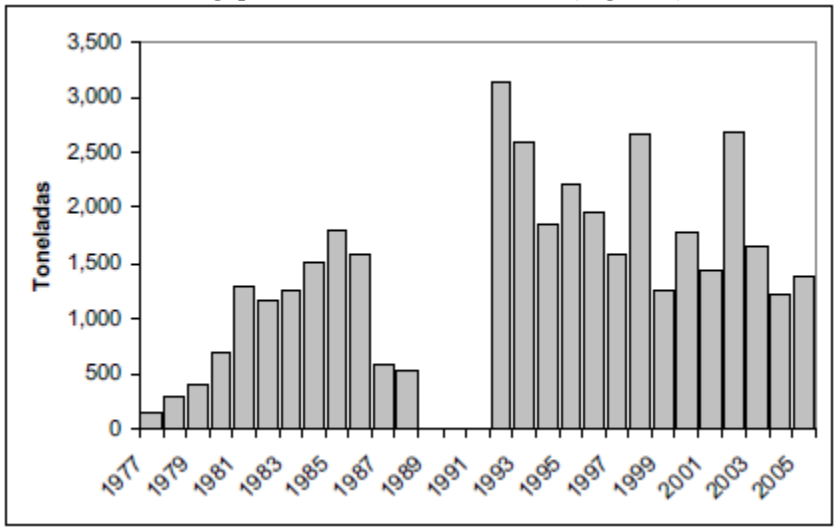

Figure 1. Queen conch (Lambí) landings in the Dominican Republic for the period 1977-2005.

Official stock assessments have not been carried out in the Dominican Republic for queen conch. Both fishery dependent and fishery-independent information are limited, which make the use of any form of evaluation difficult. There are however, some analyses of the population and the fishery have been undertaken by different researchers, including those to assess density and abundance through transect surveys (see Abundance Survey section), CPUE analyses, size/sex composition of the stock; and surveys

of dive fishermen and boats in the main conch fishing areas. Some of the main studies are summarized below.

In the Trudillé area, Infante and Silva (1992) estimated CPUEs of 40.84 and 21.47 kg/trip/boat for diving and free diving and compressor, respectively. This suggests that during the period 92-93 there was an increased production of *S. gigas* with lower effort, even though the number of boats and fishing units tripled in relation to those reported by Colom et al (1990).

In 1992, Tejeda estimated a CPUE of 39.93 kg / trip / boat. The largest catches were recorded in Trudillé, with compressor diving as the main fishing method. In another study, Tejeda (1995) estimated a CPUE of 49.26 kg / trip / boat. Based on the size structure of the catch, Tejeda (2005) observed that the size of 97% of the exploited stock in the PNJ ranged between 11-25 cm, under the legal size. Females represented 69.2% and males, 30.8%.

According to interviews with fishermen in Jaragua National Park, in the past fishermen in the area could capture 600 lbs/day at at 7m deep. Today, a diver with compressor needs to dive to depths of 30 m or more to get half the catch as 30 years ago.

These assorted population studies, anecdotal information, and results from abundance surveys and biometric analyses have indicated that the conch fishery is too intense, that fishing effort is high, that juveniles are overexploited, and that current fishing levels are not sustainable. It is urgent to undertake a more structured assessment of the status of the stocks, otherwise, management measures will have to be strengthened to be more precautionary.

In September 2003, CITES determined that the species was overexploited in the DR, and implemented the prohibition for exporting conch until basic research could evaluate the status of the stock. CITES recommended the establishment of conservative quotas for catch and exports, and to establish a monitoring and collection program to ensure that quotas are not exceeded (FAO, 2009).

Management System

Decision-making Process

In the past 20 years, administrative responsibility for the management of the fishing sector including aquaculture has changed a number of times and passed through several Ministries and Departments. The current fishery authority, CODOPESCA was created by Chapter III of the Law of fishing and Aquaculture in 2004. Unfortunately, it appears that the division of responsibilities between CODOPESCA, the Navy, the Ministry of the Environment and others is still unclear, leads to a duplication of efforts and presents an obstacle to the implementation of a realistic management plan, the allocation of budget, the provision of required logistical support (such as vehicles and at-sea enforcement craft) and the effective collaboration among agencies.

Various responsibilities in CODOPESCA are assumed by the Board of Directors, four directorates (Executive, Administration and Finance, Human Resources and Fishery Resources), the Departments for Fishery Regulations, Fish Farming and Capture Fisheries, and the Regional Service Stations. CODOPESCA is based in number of departments with staff located in the Santo Domingo headquarters and the nine regional offices.

Recognizing that a consultation process that regularly seeks and accepts relevant information, including the traditional knowledge of fishery communities is important for the implementation of a sustainable fishery management system, CODEPESCA was created by Law 307-04, Art. 7 . The CODOPESCA

Board is the highest authority for direction, decision making and control of the institution. It is composed of public and private entities involved in the fisheries and aquaculture sector, with representatives from 14 agencies or groups, including the Ministry of Agriculture (that presides), the Ministry of Environment and Natural Resources; IDEAF, the Navy, the Agricultural Bank, the Institute for Development and Cooperative Credit, a representative of the fishing companies and a representative of the Association of Aquaculture.

One main function of the Board is to revise and update regulations in consultation with a Technical Advisory Committee. This Committee is constituted by the Director of Fisheries (Chairman), the Manager of the Fisheries Regulations Department (Secretary) Fisheries, the manager of the Legal Department, together with the appropriate Department Manager (Capture Fisheries, Aquaculture and / or the manager of the Service Station where the issue arises), shall have jurisdiction to decide the viability of a particular authorization or cancellation of authorization under the law 307-04 on Fisheries and Aquaculture (ACP Fish II, 2012).

In practice, the CODOPESCA Board has never met, so the decision-making process is basically theoretical and consultation with stakeholders does not happen. All management decisions are centralized, made by higher government officials.

Fishery Objectives

The overall objective of fisheries management in the Dominican Republic is to establish a sustainable fisheries and aquaculture production system, based on the principles of responsible fishing and rational and sustainable use of the environment (FAO, 2009). Fishery-specific objectives have not been developed. A Fishery Management Plan for Queen Conch has been drafted under CRFM, but has not been finalized.

Management Measures and Regulations

The relevant legislation for management of the conch resource in the Dominican Republic is Act 307 of December 15, 2004 that creates the Dominican Council of Fisheries and Aquaculture (CODOPESCA) and the General Law of the Environment and Natural Resources Law 64-00.
Some regulations are in force in the Dominican Republic to protect the queen conch populations. Decree 833-03 dated August 25, 2003 states:

- A national seasonal closure July 1 to October 31 each year.
- Prohibits the capture and sale of conch meat during the seasonal closure.
- Capture size of 180 mm shell length.
- Closed areas as reserves from conch harvest in the area of the Catuano Canal in the Eastern National Park and in the area of Alto Velo Island in the Jaragua National Park.

Some articles in Fisheries Law 307 of 3rd December 2004 establishes some general regulations that have application to the capture and commercialization of *Strombus gigas*. These include:

Art. 27: Regulations for import and export permits.
Art. 39: Prohibition to fish without authorization during closed periods.
Art. 57: Catch limits for queen conch by size/weight and during the reproductive season;
Art. 58: Prohibition to catch juvenile *Srombus gigas*.
Art. 59: Prohibition to possess, commercialize and process queen conch individuals below 227 grams (0.5 lb) meat weight, and/or less than 20 cm siphonal shell length.
Art. 61: Prohibition to capture reproductive individuals, with eggs attached, or during the spawning season.
Art. 64: In the fishery reserve areas, it is prohibited to use gillnets, compressors for dive fisheries; and dive fishing at night.

Executive Decree Num. 1288-2004 regulates trade of the species listed in the CITES appendices, including *Strombus gigas*. The Dominican Republic prohibited conch exports since September 29th, 2003, in response to CITES' recommendations. The moratorium was implemented on Nov. 3rd, 2003, and is still valid ten years later.

Executive Decree Num N833-03 d/f 25 establishes the seasonal closure for *Strombus gigas*. This closure can only be lifted in agreement with the CITES authorities, after pondering the possibility of catch quotas, based on density studies (FAO, 2009).

Table 4 Current management controls which are being applied

Control	Strength/Weakness	Evaluation
No take of Immature Conch Size Limits: - Shell Length >20 cm - Meat weight >227 grams (0.5 lb)	Cannot be enforced for most of the fishery because shells are discarded at sea. Conversion factors for the DR are available, but enforcement of meat weight also difficult, unless samples are taken at points of landing.	Analyses of size composition suggest that size limit is not applied; the large majority of harvested conchs are < minimum length. Need new size composition to evaluate.
Closed Season (July 1st- 30 October, 4 months)	It is one month longer than the harmonized regulation (1st July-30th September); objective is to protect the reproductive stock during the peak of the spawning season. Reduces fishing effort, but by how much is uncertain. The impact on livelihoods is unclear. There is high incidence of illegal fishing during the closure.	Based on scientific studies by Aldana and others. A closed season requires effort and catch monitoring during the closure covering all fishing (landing sites, markets, processors).
Closed Areas	Two no-fishing areas specific for conch: Canal Tatuano and Jaragua National Park (established 7 July 2009). Protected areas may serve as nurseries and protect some proportion of the population. In general, unless regularly patrolled, MPAs are difficult to enforce.	These areas were selected based on high densities of juvenile conchs. Surveys have been undertaken in the closed areas; periodic surveys should help to estimate trends in abundance within and outside closed areas. There are no evaluations of the effectiveness of closed areas to protect conch in the DR.

Enforcement

The monitoring, control and surveillance (MCS) of fishing activity is the responsibility of CODOPESCA, the Navy and the Ministry of Environment and Natural Resources. There are a number of issues. (i) A

large number of fishermen and buyers failing to respect regulations on gear, minimum catch sizes, closed areas and closed seasons; (ii) Poor management practices such as low fines and inappropriate sanctions serve to undermine the effectiveness of the legislation and related regulations; (iii) Limited number of fish inspectors and data collectors, required equipment and logistical support.

According to the experts interviewed at CODOPESCA, most fishermen are aware of the laws, regulations, and sanctions, which in theory can be severe, including imprisonment.
The incursion of foreigners in the DR to harvest queen conch is minimal, only perhaps of Haitian origin. The major MCS problem is IUU fishing by Dominicans fishing in foreign waters, particularly in the Bahamas and the Turks and Caicos Islands. Local production is estimated at an average of 80 tons, but the total really approximates 350 tons, so 75% is illegal catch from other countries.

The only enforcement related to the conch fishery consists in declaration of product prior to the seasonal closure. Patrols are not organized. The Navy arrests illegal fishers at sea, and at port, they occasionally report illegal conch landings to the Ministry of the Environment, that has no authority over fisheries issues. Enforcement of the size limit is impossible since fishermen land conch without the shell, so the size cannot be determined.

Enforcement is generally not effective at most stations around the country, except in the south where there is more artisanal production. In the north the control system is very limited. Conch is distributed to hotels, restaurants, markets, etc, but the main point of consumption is Santo Domingo.

Management Options

The entire fishery management system in the Dominican Republic needs to be revised. There are a number of options to improve each of the components of the management system, which are described in the following paragraphs. Emphasis is made on those that may be feasible (financially and logistically) in the near future, that are priority to CODEPESCA, and that were discussed during the site visit.

Harvest Strategy

A harvest strategy consists of various linked components, which, taken together, ensure sustainable harvest. The three components are harvest control rule, which limits catches, the information which the rule uses, and the decision-making process which applies the rule. Only some spare elements of the harvest strategy are present in the management system of the Dominican Republic and they do not appear to be systematically linked. To revamp the whole management system, it is best to consider that the harvest strategy is at the initial stages of development, where the existing elements that are useful will be preserved. Thus, the first step will be the collection of appropriate information that will begin to feed the system and will lead to the next phases (assessment, development of HCR, development of appropriate management controls). Several specific recommendations for data collection are provided in the next section.

To be effective, any controls must limit or reduce catches. The main controls in the DR are the seasonal closure, the size limit, and the marine reserves, but enforcement is limited and compliance, apparently low.

All controls should be evaluated, which will require an appropriate monitoring system. For this reason too, most of the recommendations in this report are targeted to the development of a better monitoring system. Without monitoring, it is possible to have regulations and controls which cost resources to implement, but in reality are of little value to the fishery. Aspra et al. (in FAO, 2009) outlined a clear

proposal to improve the data collection in conch fisheries. It is worth revisiting those options and adapting them to the Dominican Republic, as in Mateo and Tejeda (2008).

In particular, the current monitoring system needs to be restructured to achieve a greater spatial coverage that includes all landing sites and beaches. There are approximately 180 landing sites and only 90 are sampled. A random sampling program could be developed.
Also, it is important to update the evaluation of the size composition to find out if a large proportion of the catch is still composed of individuals below the legal size (up to 97% according to Tejeda, 2005). Monitoring juveniles in the catch is more feasible than regular monitoring surveys. The other controls (seasonal and area closures) are more difficult to evaluate, but worth evaluating, to improve, modify, or substitute by other more effective methods.

Given the value and importance of the conch fishery of the Dominican Republic more resources need to be made available to CODOPESCA. Currently, several activities required in a complete management system are weak or lacking (notably monitoring of total catch, abundance surveys, basic biological research, analysis of information, feedback between research and management, enforcement), while significant resources are spent in the routine collection and entry of incomplete data (regular trip interviews only at certain landing sites), that are never analyzed.

In summary, CODOPESCA currently lacks the sufficient capacity, primarily trained staff (biologists and enumerators) and the financial resources, to collect, analyze, and manage the information required for good fisheries management and to support field officers who can conduct regular patrols and enforce the law.

In addition, before the CITES prohibition in 2003, the conch export market was an important source of foreign exchange to the DR, so there is also an important economic incentive for the government and the industry to comply with the CITES requirement. This situation represents an opportunity to restructure the fishery and the management system at once, with likely benefits to other fisheries as well.

Some ideas for management interventions that could be used to reduce the exploitation rate in the Dominican Republic are provided in *Table 5*.

Table 5. Management interventions that could be used to reduce the exploitation rate on conch in the Dominican Republic

Management Intervention	Background	Issues	Monitoring
Expand marine protected areas (MPAs) network	Current queen conch reserves do not cover significant conch habitat.	MPAs will need to cover more fishing areas (in the Caribbean and Atlantic) to be effective. It may be slow to get agreement on MPAs from stakeholders.	Spatial data will be required, including abundance surveys to ensure significant biomass is being protected.
Gear control: Ban use of compressed air on vessels when landing conch	This would prevent fishing on parts of the population (mainly older conch).	Similar to MPAs, but protection would be for more mature conch. This would reduce catches if enforced.	Needs monitoring and enforcement at landing points and at sea. Size and maturity composition data will be required for evaluation. It may be possible to require that fishermen/ processors also collect simple size composition data (e.g. mean meat weight).
Better enforcement of regulation: Ban landing of immature conch (size limit)	Preventing the fishery landing of immature conch attempts to ensure conch spawn at least once before they are caught as well as catch them at an optimal size.	It will be necessary to require that conch are landed in the shell, uncleaned or partially cleaned dependent upon how maturity would be measured. It is not necessary for an exact maturity measure to get the desired result.	
Effort limits	Provided in the law but not implemented. Analyses since the 90's show that effort levels increase 7-8% per year; these are not sustainable.	Would require limiting fishing licenses and implementing licenses specific for conch.	Needs monitoring and direct control on (dive) fishing effort.
Catch quotas	Has been proposed as an alternative to the closed season. It is provided in the Law but quotas have not implemented in any fishery.	Need solid scientific justification (eg. estimates of total abundance by area) Difficult to allocate quotas to many fishers who may not form part of an organization. To make quota allocation more feasible, fishermen associations or coops need to be formed or consolidated,	Needs monitoring and direct control on all catches.

Decision-making Process

There are a few essential options to achieve improvements in management organisation in the Dominican Republic:

1. During the site visit it was evident that the transfer of the fishery department from one government agency to another has created inter-agency conflicts, no cooperation, and that there has been significant loss of information (fishery data) over time. It is necessary to recuperate important historical data that could help in the analysis of the Dominican fisheries.

2. According to the ACP Fish Fisheries policy document findings (ACP Fish II, 2012), communications, planning, training and logistical support are essential four key elements that require attention to make CODOPESCA (and fisheries management in the DR) more effective in structural and operational terms.

3. Those same general needs apply to the management of the queen conch fishery.
   Planning includes developing the research projects that are urgently needed to understand the distribution, abundance and status of the conch stocks; collecting the appropriate information and analyzing it; and developing feedback mechanisms between information and harvest controls.
   Training includes capacity building within CODEPESCA, training enumerators to collect better and more detailed (species) data; train fishery biologists and statisticians and staff to capture, process, store, analyze the data; education programs for fishermen and other stakeholders.
   Training includes training enumerators to collect the data; hiring more biologists and statisticians that can understand, analyze, process the information, and provide management recommendations to managers; training in database management; education programs for fishermen and other stakeholders. Processors and fishermen also need to be instructed on the importance of reporting to generate data that can be used to better guide management decisions.

4. Stakeholder participation in management is necessary. If representation is sufficient in the CODOPESCA Board, stakeholders need to push this entity to initiate regular meetings. The fishing community and other stakeholder groups such as universities, processors, and NGOs must be able to represent their views on management and contribute to decisions in a transparent way.

Information and Assessment

There are several aspects that affect the efficiency of fishery data collection program in the DR: (i) the lack of funds to hire more data collectors with higher education, which would improve monitoring of fishers' activities in the field; (ii) there is not a clear methodology for the measurement of quantities, so there is not a basis to determine statistical error of the estimates (population size, sample size, sampling error, etc.). The method currently used is to estimate total catch from a data sample. There is a lack of data on fishing capacity and the statistics provided are not geared to monitoring fishing activity in terms of distribution and control (ACP Fish II, 2012).

The basis for the decision-making is the information being collected, which is poor. Poor information increases uncertainty and makes it particularly hard to reach agreement on difficult decisions, such as those limiting catches. The status of the conch stock(s) in the Dominican Republic is uncertain, so it is difficult for the government to manage the conch fishery without the most basic knowledge, or any current indicators of where the stock stands. While there is some monitoring of the catch, only summary statistics and an overall (multispecies) CPUE are produced periodically for the statistic reports of CODOPESCA. In addition, there is no link between monitoring, assessment, and management. Actually,

the data collected are not used to feed the management system. Management measures for queen conch are in place because of harmonized regional management, but are not based on the characteristics of the stock or the fishery. The information system needs to be the foundation of the entire management process, so the data collections needs to be expanded and strengthened, so proper analyses can begin to be carried out and begin to answer the key management questions.

Major assumptions would be needed to sort the effort used in dive trips. Rather, effort by gear and target species needs to be recorded. With more detailed trip interviews, CPUEs could be constructed and used to calibrate simple, biomass-dynamic models. If the fishery data collection programs are continued and expanded as proposed in Table 3, other forms of analyses could be undertaken.

At this point, it would be premature to propose any assessment methods that would require more detailed information and long time series of catch and effort data. Two good ways to begin analyses would be, first to carry out a more comprehensive abundance survey around the country, to assess the stocks in the Atlantic and in the Caribbean. Second, using the fishery-dependent data, if the fishing effort targeting conch in each fishing trip can be disaggregated, to calculate CPUE and attempt a production model assessment.

Once again, it is worth reiterating that one of the main problems faced by CODOPESCA is the limited number of technical staff and enumerators and the lack of financial and logistic support from the Ministry and higher spheres of government to provide continuity to fishery data collection programs.
To achieve sustainable management of the queen conch resource it is necessary to have an Action Plan to consolidate a system of standardized data collection in all the fishing areas of the country, as well as a monitoring, control and surveillance of all fishing activities and marketing of the resource. The latter cannot be achieved without the cooperation from other agencies including the Chief of the Navy and the Environmental Police. Also, collaboration from the fishing industry (who own the boats and fishing gear) is required (Mateo and Tejeda, 2008).

Monitoring, Control, and Surveillance

Any strategy to improve the effectiveness of MCS should be considered: increased compliance with regulations by users; the implementation of a cost effective integrated approach to MCS; improved management efficiency; and the establishment of effective sanctions to deter illegal fishing practices. The strengthening of inspection and surveillance activities is a priority. Inspectors must work in collaboration with the competent authorities to carry out a monthly compliance plan based on risk analysis, the availability of resources and the provision of the required logistical support. (ACP Fish II, 2012).

In the queen conch fishery, the main problem is IUU fishing. An observer program would provide an idea of the volume captured and commercialized that does not appear in the landing forms.

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Appendix A to Annex 3: List of people interviewed

The following people participated in the interviews and those marked with (*) provided most of the information on the fisheries management system and the current data collection in the Dominican Republic.

Name	Organization	Position
Jeannette Mateo	CODOPESCA	Director
** Raúl González Pantaleón	CODOPESCA	Chief Capture Fisheries Department
José Infante	CODOPESCA	Chief Regulatory Department

Appendix B to Annex 3: Main Activities Conducted

The case study involved a trip to the Dominican Republic March 9-16, 2013.

Date	Location	Main Activity
9-10 March	Hotel Santo Domingo	Arrive and prepare for meetings
11 March	CODOPESCA (Consejo Dominicano de Pesca y Acuacultura) and Ministry of Agriculture	Meetings at CODOPESCA -Introduction of the project to the Ministry of Agriculture. Attended by J. Mateo, R. González, other CODOPESCA and Ministry staff -Intro to the DR fishery with Jeanette Mateo (Director Fisheries) -Description of data collections by Raul Gonzalez
12 March	CODOPESCA Capture Fisheries Division	Meeting with Raul Gonzalez: Data collections, analysis and Fishery management checklist. Brief SICA interview.
13 March	CODOPESCA	DR document and data review Interview with chief of the Regulatory Department (José Infante) DR document review
14 March	CODOPESCA	DR document and data review
15 March	CODOPESCA	Discussions of needs, priorities, recommendations, possible methods for stock assessment (Jeanette Mateo and Raul Gonzalez)
16 March	Depart	

Appendix C to Annex 3: Beach Activity Log (*Translated from CODOPESCA Sistema Nacional de Levantamiento de Información Pesquera)

CONSEJO DOMINICANO DE PESCA Y ACUICULTURA

CODOPESCA

Law 307-04

BEACH ACTIVITY LOG

STATION	BEACH	PROVINCE	MONTH	YEAR

			Date														
	Vessel	Fisherman															
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
…																	
30																	

Total Active Vessels															
Total Inactive Vessels															
Total Vessels at the Beach															

CODE Fishing Gears

At	=	Atarraya	Nb	=	Nasa del Bajo	Lcu	=	Curricán
P	=	Palangre	Char	=	Chinchorro arrastre	Lvb	=	Balsa/Viveo
			Lco	=	Línea cordel	Ll	=	Línea Luz
Nc	=	Nasa Chillera	Tl	=	Trasmallo langostero	Bc	=	Compressor Dive
Chah	=	Chinchorro Ahorque	Lca	=	Línea cala	Bp	=	Free Dive

Appendix D to Annex 3: Landing and Sales Log (**Translated from CODOPESCA Sistema Nacional de Levantamiento de Información Pesquera)

CONSEJO DOMINICANO DE PESCA Y ACUICULTURA

(Law 307-04)

LANDING AND SALES LOG

Station			
Province			
Beach			
Fisherman/Captain			
Fishing Location			
Depth		Date	
Gears		Num. Gears	
Departure time		Return time	
Date of last lift (traps)		Vessel Name	

	Class	Weight	Price	Sales value
FISH	First			
	Second Red			
	Second White			
	Third			
	Fourth			
	Other			

CRUSTACEANS	Lobster			
	Shrimp			
	"Centollas"			
	"Dormilonas"			
	"Siricas"			
	Others			
MOLUSCOS	Lambí			
	Octopus			
	Squid			
	Clams			
	Others			
TOTAL				

OPERATION COSTS

Concept	Quantity	Price	Total
Gasoline			
Oil			
Ice			

Bulk Income	Combined Expenses	% Equipment	Net Income	% Captain	% Fishermen

Enumerator _____

Appendix E to Annex 3. DOMINICAN REPUBLIC - ACP Fish II Conch Fishery Information Checklist.
The following notes are provided from interviews with the CODOPESCA staff, and information gained was used to inform the report. The notes presented contain information that are the views of local staff and include information beyond the scope of this study. (Interviews were conducted March 11-15, 2013 at CODOPESCA (Consejo Dominicano de Pesca y Acuacultura) in Santo Domingo, DR).

Stock Assessment and Management

Conch Management Issues	Main Questions	Response
Life History	• Has there been any local research on conch life history and ecology?	See National Conch Report in references "Informe Nacional de Lambi"; Torres & Sullivan and others There are no data from the fishery in the 1970s.
Stock Structure	• Is the conch within your waters treated as a separate management unit, or is the stock shared with other countries, or are there sub-populations that should be managed separately?	The Banks are separate: Caribbean and Atlantic. There is a difference between them- the Orinoco current in the Caribbean and the Gulf current in the Atlantic. The Caribbean is nutrient-poor, while the Atlantic is highly productive, but the insular shelf is very narrow (<1km). There are different fishing areas, but they are homogenous in the Atlantic and also homogenous in the Caribbean. Jaragua Park is a fishing zone, but is not a conch bank. Assessments must be carried out separately for the Atlantic and the Caribbean regions of the DR; and a 3rd subpopulation in East Park, where there is sewage discharge, tourism, golf courts and phosphate and sulphate discharge into the water. The conch populations are decimated because the species is highly associated to the (deteriorated) substrate, but Perciformes and lobsters persist.
Monitoring Data Types	• Is the fishery routinely monitored and if so how is that carried out? • How are the data managed and stored?	Catch data are collected through landing records at the landing sites. Only the meat is recorded, as shells are discarded at sea. Conch mounds ("*concheros*") practically do not exist anymore. All the Taino deposits have conch shells; taino natives used to land conch in the Shell. In Beata and Alto Belo there are pre-taino conch deposits. There is an Access database, exclusive for the landing records. There are data-entry staff at the central office who enter the data in Access. The landing logbooks are sent to the central office on a monthly basis. A report of the landings, catches and days observed is produced every 3 months. 2 staff members conduct the analyses of landings data. One person analyzes the raw data by landing site and another person estimates the national production. There are Annual Reports from 2008 to 2012.

		The database is stored in a personal computer and will soon be backed up on a server donated by ACP Fish II.
Abundance and Density Indices	• Do you have an abundance index, for example based on CPUE or surveys?	There is a catch index, NOT an index of population density by hectare. This index is catch by effort (see document with explanation of CPUE estimation- "Informe de Memoria enero-octubre 2012"). See CITES reports by Appeldoorn, Mateo, Nemeth & Posada at Jaragua Park and Montecristi; Density study in Eastern Park by Sullivan & Ruben Torres The last density study (in 2003) did not provide reliable results. In the southern region the volumen of catches is stable. It is worthwhile to examine variations in effort and CPUE.
Catch Data	• Are all catches recorded, or is there a significant catch which is unrecorded, such as subsistence and local landings? • Are there any conch processors and do they report conch purchases or exports? • Is there significant IUU fishing?	Everything is reported, but a component is based on estimations. Catches are only reported on the days observed. The coverage is 45-46%. The subsistence and commercial catches are mixed; the marginal profit is minimum for the subsistence fisher is minimal, but even if the product is sold, it is still subsistence (2-3 lb). The commercial fishery thus has a subsistence component, with a limited marginal benefit (of $400 to $600 pesos). Fishers make more than the minimum wage, more than an agricultural worker. If someone invests 51% of their time fishing, that person is a fisherman. Yes, there are conch processors; they record purchases and exports. Yes, there is significant but unknown IUU fishing; conch fished illegally in other countries (Bahamas, Turks and Caicos) by Dominicans is landed in the northwest coast, mainly Puerto Plata. Perhaps up to 75% is illegal catch from other countries.
Effort Data	• Are you able to estimate or record fishing effort? If so, how is it measured?	Yes, Total effort only, see references (Estimation of Catch index in "Informe de Memoria enero-octubre 2012"). Being a multi-species fishery, only the total effort (using multiple gears to catch multiple species) is recorded. The effort spent on each target species is unknown. Trips targeting conch can be identified by the gear (free diving or hookah). However, conch fishers are specialized, they target conch, they are generally not multi-specific. Other fishers target fish, but if they find conch, they will pick it up.
Vessels and gear	• Do you have information on the vessels that catch conch and their gear, such as might be held in a vessel register or licensing system?	Yes, there is information, but the commercial fishing licenses are multi-specific. There are also permits to harvest and commercialize lobster. Exploitation permits are given to a company that has specific gears. There are no such permits for conch because there is no need; conch fishermen offer the product to dealers.

Management Strategy	• How does the fishery management ensure the stock is not overfished?	Nobody knows the status of the stock; monitoring is needed.
Target and limit reference points	• Do you have target and limit reference points set for the conch stock?	NO reference points exist, but the objective is Maximum Sustainable Yield. There is a significant capture of juveniles. Objectives are laid in the in the General Fisheries Law: (1964) *Ley General de Pesca 2004- Ley 307-04 CODOPESCA*
Harvest control rules	• Do you use pre-defined decision rules to control the level of harvest?	Yes. Seasonal closure, minimum size and weight restrictions, compressor diving prohibited (since 2004). Regulations are currently in review (to be accepted). Conch is regulated in the Law, there is no need for regulations. However, there is no scientific basis to support to the regulations, they need to be updated on this basis.
Implementation of the harvest control rules	• How do you control the level of harvest? • How would the harvest be reduced if overfishing was detected?	The level of harvest is not controled, there are only management measures to protect the spawning stock. There are tools to manage the resource at CODOPESCA. There are estimates of the volume harvested, the effort, the economic variables, but the biological/ ecological part is missing. There is a lack of human and financial resources for this. The Law establishes a catch limit (eg, 200 mt), can be applied to queen conch. The Law also establishes that CODOPESCA has the ability to limit harvest, but this has not been done in any fishery. Also, CODOPESCA can limit fishing effort. There is an intention to limit the number of fishing licenses. Some reports calculate an annual growth of 7-8% in the number of fishermen and vessels. The 1st comprehensive census was conducted in 1990; in some areas effort has declined, in other areas, not much variation has been observed.
Assessment and Analysis	• What assessment and analyses are carried out on the available data (please provide any documents if possible)?	Analyses of the landings up to catch composition. Landing volumes. The fishery is multi-specific. It is very difficult to analyze each fishery separately. The national production is estimated as general trends, but by fishery there is a greater error margin. Catch and landings are reported in CPUE (kilograms per landing). Effort is in the number of observation days. Tables of Catch, Fo (effort) and CPUE by province are produced. The observation days are the days when landings are reported.
Stock Assessment	• Have you had a stock assessment completed? • What method was used to assess the stock?	No, no recent stock assessment. Mateo and Appeldoorn did a survey sampling transects and estimated population density (in the 1990s). In the DR, conch is fished at greater depths, the density has declined as more effort is applied with the use of compressors, even if they are prohibited. Both juveniles and adults are captured in deeper areas.

Robustness of the assessment to uncertainties and assumptions	• If you have an assessment, have the uncertainties and assumptions assessed? • Are these uncertainties reflected in management advice?	NO
Stock status relative to reference points and projections of HCR	• Has the stock status been evaluated relative to reference points? • Have the decision rules been tested to ensure they work and are precautionary?	NO
Management Controls	• For each management control that is applied, it would be useful to know whether their effectiveness has been evaluated.	
Area Closures	• Are any areas closed to fishing conch? • Have these areas, if any, been designed to protect part of the conch stock?	Yes, there are protected areas, 2 no-fishing zones: Tatuano Channel and Jaragua National Park (declared 7 July 2009). Yes, these areas were designed specifically to protect conch because large densities of juveniles have been detected there.
Seasonal closure	• Are there closed seasons for conch and if so when are they applied?	Yes, there are closed seasons; the objective is to protect the spawning stock, based on the reproductive peak. Decree 499- National closure for 4 months, based on scientific studies by Aldana and others.

Effort Limit	• What are the limits on fishing effort (licencing, number of fishermen, alternative livelihoods)?	Effort limits are needed and are contemplated in the Law, but have not been implemented. There are general fishing licenses; specific permits by species are only available for some industrial fisheries, not for queen conch. By Law CODOPESCA has the authority to limit effort, but a policy to implement effort limits has not been developed. The census is being updated, the total number of vessels is estimated at 4100-4200 vessels. So far 3,600 vessels have been counted; the southern, Caribbean region has not been surveyed yet. There are 37 vessels in Puerto Plata. The last census was in 1990, although updates of the number of vessels by region have been carried out at times. The current census is comprehensive, covers the entire country and includes data on the type of vessel, fishing gears, mapping and codes of landing sites by region. Permits include: Fisher license, vessel license, exploitation license, commercialization license, no objection permit for importing and exporting, no objection permit for scientific research, agreements for co-management, research agreements with universities to do research and supervise theses. Most permits are for fisheries exploitation. Capture permits for queen conch are not common.
Catch Limit	• Is any sort of catch limit (quota) applied to conch?	NO, catch limits are contemplated in the Law but quotas or limits have not been established.
Sizes Limits	• Is there a size limit (flared lip, shell length, lip thickness, meat weight)?	YES
Bag limits	• Is there a bag limit, and if so to which sector of the fishery does it apply (recreational, subsistence, commercial)?	NO
Other limits	• Are any other limits or controls?	NO

Management System

Conch Management Issues	Main Questions	Response
Decision-making	• How are decisions on fishery management made? • Who is responsible for the different roles in decision-making (gathering information, giving scientific advice, making the final decision)? • Who is involved in the decision-making process (advisory bodies, stakeholder consultation, Ministerial structures)?	Decisions are centralized, made by the Government. There is a council formed by representatives of 14 different institutions, but in practice the executive director makes the decisions. The Fisheries Council (see Fisheries Law) has never met. Regulations are proposed by CODOPESCA and are issued by Presidential Decrees (eg., Queen Conch Decree,"*Decreto Lambi*")
Policy	• Is there a policy document or fishery management plan, with clear objectives stated for the conch fishery? • Does government policy include the precautionary approach?	NO, there is no management plan. The Queen Conch Decree (*Decreto de Lambi 499-09*) contains the main objectives and establishes the closed seasons and closed areas for queen conch. The Fisheries Law of 2004 and Regulations, and Decrees No. 312-86 (minimum size), No. 269-99 (seasonal closure in the whole territory), No.833-03 (regulations for fishing and commercialization of conch) are the main policy documents that guide management of the queen conch fishery.
Review	• Have there been any independent reviews of the management plan and/or scientific assessments?	There was a scientific evaluation of the resource in 2003, but no documents are available of the conch survey. There is no consultation process, the University does not work with queen conch. To do an effective project with queen conch, a large project needs to be set up, with boats and money for 4-5 divers. The vessel satellite monitoring from OSPESCA was delayed and may not be implemented.
Research Plan	• Have you identified research needs necessary for the sustainable management of conch? • Is there a research plan that identifies research objectives, activities and funding?	YES, there is a research plan, but no resources to implement research projects.

Compliance	• Are fishers aware of the laws, regulations and sanctions? • To what degree do fishers, including foreign fishers, comply with fishery regulations and laws? • What enforcement is carried out? • Are there incentives to fish sustainably (e.g. long term investment in the fishery, training and education, security of tenure etc.)?	- Yes, fishers are aware of the laws, etc., even if they say they are not. Most fishers are older, over 30 years old because fishing is not an attractive activity. - Sanctions are contemplated in the law; some are harsh, including jail time. - Compliance is low. Some Haitians fish in Dominican waters, but not so much for conch. There is low incursion of foreigners in the DR, but Dominicans fish illegally in the Bahamas and the Turks and Caicos. - Enforcement activities include: declarations of product prior to the seasonal closure; capture of illegal fishers by the navy. At port, occasionally the Navy reports illegal fishers to the Ministry of the Environment, but this agency is not involved in fisheries issues. - In Sto.Domingo no MCS activities occur, but at regional stations there are declarations at the beginning of the closed season, and regular inspections during the closure. - Enforcement of the minimum size is not possible because they discard the shell and only bring the meat, so there is no direct way to determine the minimum size. - Enforcement is not very effective at most stations, but in the southern region, where most of the production is artisanal, the enforcement staff is very effective. In the north, the control system is not soy large. Conch is distributed to hotels, restaurants, etc., but the main point of consumption is Santo Domingo. - There are no incentives to fish sustainably. At the national level, there is no problem with the conch fishery, because there a significant proportion of the production is from illegal fishing (of Dominicans) in other countries. The domestic production is ~80 tons, but total production is 350 tons, so ¾ of the production comes from illegal catch in foreign countries.

Ecological impacts

Conch Management Issues	Main Questions	Response
Habitat	• Has conch habitat (depth contours, biotopes etc.) been mapped? • Is data on habitat held on a GIS? • Are the main fishing areas mapped? • Are there thought to be any significant impacts on habitat associated with the conch fishery?	-Yes, Jaragua Park and Eastern Park have been mapped. There are aerial photos of possible conch habitats. -Conch is a species with limited movement, so compressor diving is creating a problem. There are conch mounds ("*conchero"*) with empty shells that work as artificial reefs, so perhaps there is a positive effect on conch habitat. A comparison of the old (prehistoric, aboriginal) conch mounds with new ones helps to understand patterns in the fishery.
Ecosystem	• Is there any local research on the role of conch in the ecosystem? • Has there been any ecosystem modeling (e.g. Ecopath) with conch as a trophic component? • Is the conch fishery likely to be having any significant impact on the local ecosystem?	The density, adult density, catch composition, proportion of juveniles, etc need to be studied. In the DR, there is no incidental fishing (bycatch). Everything is consumed, CODOPESCA is even finding market opportunities for the lionfish. There are problems with trawl nets because they catch everything, including juveniles of many species, but all the fish products are transformed into fish balls for human consumption. Even the sharks and rays are consumed, every part is utilized. The continental shelf is narrow, so all the catch is used. In the DR, there is only one fishery that harvest everything. One student did research on predation of queen conch (Alex Tewfik). Density studies were conducted with grupo Jaragua.

Annex 4: Grenada Case Study

Background

Country Visit

The country visit was an essential element to conduct the national case study in Grenada. The visit was conducted from March 25-29, 2013. The purpose of site visit was to evaluate the possibilities of enhancing scientific research to inform management decisions and to support a sustainable queen conch fishery. A number of activities were performed, including interviews with key scientists and managers, fishermen from different areas, and visits to some of the main queen conch (Lambi) fishing areas and fish markets. A preliminary analysis of the data is provided in Appendix A; a list of the key people interviewed in Appendix B, and a summary of the activities conducted in Appendix C. Most of the information was provided by staff of the Fisheries Division of the Ministry of Agriculture, Lands, Forestry and Fisheries. The results presented here summarize the perceptions of all the stakeholders and the data and reports analyzed.

The main objective of the country visit was to obtain first-hand information about the queen conch fishery, the status of the stock, the data collections and the components of the management system. Emphasis was made on evaluating the existing (or necessary) methods to collect and analyze catch and effort data, as well as those to conduct biological surveys or fishery-independent monitoring activities.

The review of the management system included the general legal framework, the fishery objectives, the harvest strategy, the research plan, and the monitoring, control and surveillance mechanisms used to ensure compliance with fishery regulations. A completed checklist of management information was created during the interviews (Appendix D), and a SICA[3] was carried out to assess the main effects of the conch fishery from an ecosystem perspective. Analysis of all of these elements unveiled the gaps in the system and the management needs for the fishery. These helped to formulate and discuss practical options to implement fishery improvement projects that would support a sustainable management framework in Grenada.

The findings from the site visit are summarized in this case study report.

Purpose of the Case Study

The objective of the case study is to improve the scientific approaches required to support sustainable management of queen conch (*Strombus gigas*) in Grenada, and in particular, consider options for incorporating scientific information into effective management strategies. The case study will provide information necessary to consider harmonising management within the region which should lead to more effective support and cooperation among CARIFORUM countries.

Description of the Fishery

Grenada is a tri-island state (including Grenada, Carriacou and Petite Martinique) of only 347 km^2, located in the Southern Caribbean, between St. Vincent and the Grenadines (North) and Trinidad and Tobago (South). Grenada has a total shelf area of 900 km^2, within which there are large areas of sand and coral rubble that support conch populations. The country supports an artisanal, small-scale, multi-species marine capture fishery that is conducted under open access conditions (FAO, 2007). Queen conch

[3] The SICA (Scale Intensity Consequence Analysis) is a risk analysis suitable for looking at complex sets of actions and impacts to isolate the riskiest activities and their likely effects. In this case, the no major consequences were found apart from the direct impact of conch fishing, so the analysis was not reproduced here.

("Lambi") is one of the main species in the "Shellfish" category that also includes spiny lobster, turtle, sea urchin and squid.
The conch fishery is important to Grenada as conch meat is used extensively by local people and as a delicacy in the tourist industry, as well as an export product. Grenada has traditionally been a supplier of conch to Trinidad, which continues to this day. The main fishing grounds occur on the north, northeast, and southern shelves and harvest is done from small wooden boats with outboard engines. Most fishermen use free diving and SCUBA gear to a depth of 50 m. The catch is landed at many landing sites throughout the island. On occasions, the fishermen save their catches in 'crawls' until ready for market (the Grenadines) and only meats are landed.

Most recent estimates of harvest are about 25 tonnes, which is thought to include a large portion of juveniles. The product is landed as uncleaned meat. Management regulations follow the Organization of Eastern Caribbean States (OECS) harmonized rules (minimum shell length of 178 mm and 225 g meat weight).

Data presently available includes some annual landings since 1978, some monthly landings since 2002, and conch exports since 2012. However the sales to local hotels and restaurants as well as some of the exports to Trinidad have not been recorded. Associated effort may be difficult to assess due to the multi-species nature of the landings (CFMC/CFRAMP, 1999).

Overview of the Harvest Strategy

Information

This review concentrated on routine data collection and management, although other research and short-term monitoring efforts were considered during the interviews. Medley (2008) conducted a review of the data collection and management systems of the marine fisheries of Grenada in 2008. The intent of this review of information was to revisit Medley's (2008) work, assess if any changes in data collection have occurred in the past 5 years, and add specific information for queen conch.

General fisheries data are collected in the form of a total sample at the six fish markets situated in each major landing area around the Island. These markets are staffed with Government paid employees, and all fish that pass through the market system are recorded. However, any fish that is landed and does not pass through the market is not recorded. It must be noted that the level of data coverage varies for different fisheries. The deep-sea large pelagic and coastal small pelagic has the highest coverage, approximately 80%. This is followed by demersal, approximately 70; then inshore pelagic, approximately 60%; and lastly the shellfish fishery, approximately 25%. There are plans to institute a more structured sampling plan to arrive at a more accurate estimate of total landings (Baldeo, 2002).

Catch-by-species-by-boat is collected on a daily basis. Effort is also collected as a total sample similar to landings. Effort is measured in boat-days due to the multiple gears used in the multi-species fishery.

The key weaknesses in the data are that a significant proportion of the total catches are unrecorded and a reliable estimate of fishing effort or CPUE is not available. No other indices of abundance are available. Programs to collect trip-interview data and size composition have only occurred periodically; biological surveys for conch have not been conducted.

The monitoring programs have not changed since 2008, and the recommendations for data collection and storage in Medley (2008) have not been implemented, mainly due to lack of funding and staff at the Fisheries Division (FD). The monitoring data types and availability of data are described below and summarized in *Tables 1 and 2*.

Catch and Effort Data

The queen conch fishery is routinely monitored through trip interviews, which contain catch and effort data. CFRAMP started TIP in the 1992 through Trip Interview forms, which then became the "Daily Fish Landing Log" (Appendix E) at fish markets. There are no data collectors from the FD, so market staff members complete the daily log. The log includes information about the location fished, the landing site, characteristics of the vessel and gear, the area fished, the time spent fishing, and the volume landed by species.

Markets send weekly reports of their daily log to the FD. These only contain the quantity of species landed by week and month (Appendix F). This weekly production data are entered electronically, but the effort data from daily sheets (number of trips, days/hours fished, number of tanks) are not. Thus, only monthy and annual summaries of landings are available, but they are not linked to effort.
Sporadically other data is collected, such as trip interviews at primary and secondary landing sites and beaches. Collection of catch, effort and biological data from fishermen at landing sites occurred only for a short period (1996-1998).

A significant amount of the queen conch catches are not recorded because they are not brought to the primary landing sites or main markets (Grenville, Spice Isle Fish House Ltd., Southern Processors). Instead, they are landed at secondary sites (beaches around the island) and sold in the street or to restaurants and hotels. There are about 15 landing sites around the main island of Grenada, none on the West coast because the shelf is very narrow, with limited habitats suitable for conch.

With regard to IUU fishing, significant illegal fishing is not known to occur, but as noted above, there is significant unreported fishing. Some poaching from neighbouring islands may occur.

Another piece of information available at the FD includes exports from processors. The main export markets are Trinidad and Barbados. Exports make up approximately 30% of the recorded catch. Most of the conch exported come from Calliste (landing site in the south) and the northern island of Carriacou. In order to export any fish or shellfish product, processors need approval from the department. They export part of the product; others freeze it and sell it to supermarkets. Processing plants have their own forms, data clerks from the FD visit them every week and extract the data.

Other conch landings are sent directly to trading vessels (currently five vessels) that go to Martinique and Barbados. This trading is added to the total catch at the FD. Licensed exporters and trading vessels are issued an export certificate per shipping, which is corroborated with a record from the customs office of what actually leaves the country.

Thus the total queen conch catch data available at the FD includes landings at main markets and export and trade records from processing facilities and trade vessels. All the data are entered in MS Excel and are kept at the Statistics department in the FD. Also, very importantly, as data are entered electronically, all catches are raised to a "lifting factor" of LF=1.75, to account for misreporting or underreporting. In theory, this adjusted catch is supposed to provide a better estimate of the total catch. However, there is no statistical basis for this raising factor, but it has been used since the 1980s, after a recommendation from a visiting scientist. It was more recently modified to 1.4 for some tuna species because most go through fish markets and are recorded in the TIP logs, although this figure too has no strong statistical basis.

It is evident that such raising factor may not hold for most species, and it needs to be revisited, on a species by species basis. The actual proportion of unreported conch landings is unknown, but the LF assumes that 57% of the total catch is recorded. In contrast, interviews suggested that 70-80% of the conch landed is marketed directly to consumers, so only about 20-30% of the catch is recorded, implying a LF of 3.0-5.0.

Vessels and gears
Vessel and gear information are recorded in the daily landing logs. These contain the catch by species by boat by day by site.

The FD issues a registration for vessels engaged in commercial fishing, and all the information about the vessel is kept in a registration database (in Excel). Vessels are supposed to renew their license and update the registration information once a year, but there are many registered vessels that change owners, don't fish anymore, etc. It is necessary to match registration information with catch, but this is not currently possible due to limited data management capabilities (see section below).

Also, according to the Fisheries Act of 1986, the FD issues fishing license to local fishing vessels, which provides the authorization to fish in Grenadian waters. It requires an inspection at sea to check that safety standards are met. Currently, there are about 800 licenses, but there are fishing records from 1771 vessels. A census is needed to verify this information.

Abundance Surveys
Surveys have not been conducted in Grenada.

Biological Sampling
Routine biological sampling of conch does not occur. The complex growth form of conch makes interpretation difficult. Shell size measures, although more reliable, are difficult to obtain as the shells are discarded at sea (Medley, 2008). Routine biological sampling of conch is of lower priority than either lobster or finfish.

Collection of biological data for adult queen conchs occurred during the period 1996 to 1998. The data[4] (N=600) included total weight (shell and meat), shell length, lip thickness, meat weight, and sex. The analyses of this information are described in (CFMC/CRFM, 2009) (see Assessment section). Biological sampling was interrupted due to limited financial resources and staff.

Fisheries officers sporadically collect this type of information in different parts of Grenada. Currently, the FD office in Grenville is calculating mean individual weights by sampling bags of conch at the Grenville market. Their results are preliminary and reports of their findings are not yet available.

Data Management
A data management system used within CARICOM and CRFM, named CARIFIS, was attempted in Grenada. The main idea of this system was to have a database that would link TIP data with the licensing and registration system (LRS), and that would create automated custom data reports. Unfortunately, CARIFIS was never suitable for Grenada's needs, even after a number of adaptations and modifications. In addition, only two persons from the FD were trained to use it, and left the department soon after.

Apparently CARIFIS was difficult to implement and manage, and required serious training. The FD still would like an automated data management system that adapts to the unique needs of Grenada, that links trip data to license and registration information, is more user-friendly, produces custom summaries, and can endure staff turnover. Meanwhile, the DF maintains the catch, export, and license and registration data in Excel spread sheets.

[4] These data are stored in floppy disks at the Fisheries Division; not available for this review. Contact Mr. Paul Phillip (Coastal Zone Management, Ministry of the Environment) for more information.

The database is inadequate for raw data storage and retrieval. There are data clerks whose job is to enter the data in Excel, and the lead clerk runs custom summaries and produces annual reports by hand. Much manpower and effort is expended in data entry and data management activities. Yet, due to limited staff, not all the data are entered electronically. In particular, the daily logs are not maintained, and weekly landings may be entered, if at all, with a time lag of at least a couple of months. Recommendations to improve the data collection system in Grenada are provided in the final section of the report. The new data that might be collected for the purposes of stock assessment and management decision making is described in *Table 3*.

Table 1 Queen conch data availability at the Grenada Fisheries Division.

Current Available Data	**Strengths and Weaknesses**
Total Catch Data	The only catches that are recorded are those purchased by the fish markets/processing facilities and exports. Catch for subsistence, or sold directly to hotels and restaurants are not recorded. The scale of the unrecorded catch (marketed directly to consumers) is not known, but suspected to be high (about 70-80% of the recorded catch). This creates a problem in determining total production. All the current catch data are collected through trip interviews at the main fish markets/ processors (see below). Export and trade data are added to the total catch.
Trip Interviews	Catch and effort data are recorded on daily logs which contain the estimated catch per species (with OECD codes) per boat per day. Most variables are recorded reasonably well, including information about the location fished, the landing site, characteristics of the vessel and gear, the area fished, and the time spent fishing. However, being a multi-species fishery, there are multiple records per boat each day, so the effort spent on each target species is unknown. Daily logs are transferred to weekly/monthly logs at the market/processing facility, then submitted (in paper form) to the Statistics office at the FD. Details are lost when market staff transfer daily logs into weekly/monthly sheets, and errors are prone when re-entering data in electronic form.
Biological Data	Biological data collection and trip Interviews are not currently conducted at landing sites for queen conch, but have occurred in the past with a high level of cooperation from fishermen. Sampling from landings in Grenada began in late 1996 and went on through 1998. Catch, effort, and size composition data were collected directly from fishers at landing sites, supervised and trained by biologists from the FD. These data were collected at two primary and a number of secondary landing sites. Conchs are not usually landed in shells, so special arrangements would have to be made with the fishermen to be able to sample the shells. These data are stored in floppy disks, not currently available at the FD.
Export Data	Available by month and species since 1993. Conch is mainly exported to Trinidad and Tobago and Barbados. The conch traded (mainly with Trinidad and Martinique) is also recorded.
Survey data	Abundance surveys for queen conch have not been conducted in Grenada.

Table 2. Details of the queen conch data available at the Fisheries Division

Data set	Description	Period	Strengths and Weaknesses
Daily Landings and Effort (Trip Interviews)	Daily catch logs available on hard copy, but only entered electronically for a brief period in 2009 and 2010. Daily landings and effort recorded on daily logs.	2002-2012 Electronic only 2 months in 2009 and a few months in 2010.	Detailed data, with info about the vessel, fishing area, gear, trip, effort, catch by species. Fishery is not well covered by enumerators for obtaining trip interviews. Electronic database is not maintained.
Weekly/Monthly Landings	Entry of species by landing site per week/month (TIP)	2002-2012	Weekly summary of daily logs. Only landings by species. Effort data is not included, trip information is lost. All data is raised by a fixed "lifting factor" of 1.75 Not all weekly logs are captured electronically.
Annual Landings	Total catch from TIP plus exports and trade	1978-2012	Summary of total catch from all sources. Significant gaps in database from unreported catch.
Exports	Exports by species by month by processor	1988- 1993 unclassified annual exports 1993-2012 exports by species by month by processor 2000-2012- cleaner exports by species	Between 1988-1993, unclassified exports, some unclassified until 1999. Detailed data only since 1993; Gap in 2005-2008 exports
Mapping data (E) (Grenadines MarSIS[5]) (CERMES, UW)	Google Earth application that maps habitats and fishing grounds in Grenada and the Grenadines	Maps (2009) are updated regularly (2013)	Maps and data of habitat distribution, marine parks, reef ecosystems, distribution of marine resource users per island. Allows adding data and creating custom maps.

[5] Grenadines MarSIS Marine Resource and Space-Use Information System http://grenadinesmarsis.com/Habitat_Mapping.html

Table 3. Queen conch data which should be maintained (EXISTING- E) and could be collected (NEW data)

Data Source	Data Type	Purpose	How it may be collected
Market and processing plant purchase receipts (E)	Total landings.	Used to estimate total biomass and fishing mortality and assess the effectiveness of catch controls.	Daily/ weekly landing logs. All commercial purchases should be recorded and reported to the FD.
Processor exports (E)	Total exports (E)	Add to total landings.	Conch exports by month.
Daily landing logs (E/NEW).	Detailed catch and effort data by trip	Get CPUE index of abundance	Detailed catch and effort data within the trip, linked to purchase receipt to get accurate catch. Effort recording needs to be improved: effort allocated to each species per trip (e.g. Conch effort in number of tanks or time in/out of dive).
Trip Interviews (NEW)	Catch and effort from trips	Estimate all catches not being landed at the processing plants. Alternative CPUE abundance index.	Interview fishermen at landing sites. They are not likely to complete Logbooks.
Biological sampling at landing sites (E-NEW)	Size, sex composition and maturity. Increase precision by stratified sampling[6].	Sex, maturity, size composition.	Sampling of shell size, weight, sex, and maturity at landing sites (need agreement with fishers to bring conch in the shell).
Size composition from markets and processors (NEW)	Increase precision by stratified sampling.	Mean individual weight of the landings.	Simple mean weight of 100% processed product could be estimated from frozen bag weight and number of pieces. A number of bags could be sampled randomly and periodically. Whenever possible, sampling individual weight of unprocessed meat would be required for accurate measures.

[6] See Medley, 2008 for details of new data collections and stratified sampling design.

Data Source	Data Type	Purpose	How it may be collected
Fishery Independent Abundance Surveys	Conch density and size structure by area and depth.	Obtain an independent abundance index or absolute measure of abundance. Set total catch quotas as a proportion of the estimated biomass. Locate areas for stock structure or special protection.	Surveys will need to be organised to cover population areas. This would require suitable vessels and divers (fishers and biologists) in suitable numbers for the areas to be covered. Surveys are likely to be expensive and need to be replicated periodically.

Assessment and Analysis

Previous Analyses

A stock assessment was attempted at a workshop held in Belize about 14 years ago (CFMC/ CFRAMP, 1999). Mostly biological data were available[7], including total weight (shell and meat), shell length, lip thickness, meat weight, sex, and effort data on the fishing activity for a number of boats sampled (which also targeted other species such as lobsters and fish on the same trip).Historical data on catch and effort were not available.

A weight-based stock assessment technique was tried; unfortunately, inadequate data prevented the analyses from obtaining any firm conclusions on the conch stock. Total catches were lacking and meat weights only comprised large mature individuals (due to Grenada's size limits). Problems in the model and data were identified and suggestions were made to improve data collection. In particular, it was recommended to continue the collection of biological data; to standardize meat weight records (percentage processing); and to determine 'true effort', as the divers do not target only conch on a fishing trip, but also other species such as lobsters and fish (CFMC/CFRAMP, 1999).

No other stock assessments have been conducted in Grenada. The FD only produces quarterly summaries of landings and exports and annual statistical reports. The level of exploitation is uncertain, and the stock is suspected to be fully exploited or overfished since 1989. There is, however, no scientific basis for this assertion, except for anecdotal information. For example, at that time, entire areas were depleted and effort had to be shifted from one area to another. Also, for a number of years, many of the conchs captured were small.

The uncertainties in stock status are not reflected in management advice, and there is no link between monitoring, assessment, and management. Management measures for queen conch are in place because of harmonized regional management. No formal scientific advice has been given based on any stock assessment.

New Analyses

The available market landings data were used in a preliminary analysis to see whether it might be possible to obtain useful management advice at least for interim controls while problems with data might be addressed. The analysis and results suggest that such analysis can provide advice, albeit results are very uncertain and advice is based on risks rather than hard scientific evidence (see Appendix A). Specifically, it may be possible to establish reference points on the only fishery indicator being monitored routinely, which is the market landings.

[7] Same as footnote (1).

Management System

Decision-making Process

The organizational structure of fisheries management in Grenada includes: the Cabinet of Ministers, the Minister of Fisheries, the Permanent Secretary and the Chief Fisheries Officer. It is not known if other organizations participate in fisheries management.
The units within the Fisheries Division are: Planning, Coordination and Management; District Extension Services; District Fish Market Centres; Fishing Technology; Fisheries Biology; Marine Protected Areas; and Refrigeration (FAO, 2007).

A diagram illustrating the management process is provided in the draft Fishery Management Plan (2007) and reproduced here (Figure 1).

In reality, this process is not fully transparent and for the majority of stakeholders, it is not clear how the different components interact. In addition, some stakeholders do not consider that they have sufficient involvement, that the Government listens to their concerns, or that they have any influence in the decisions. Another major problem is that there is no budget for fishery research programs; therefore there is practically no research to guide management decisions. NGOs do not appear to play an important role in the fisheries management of Grenada.

According to government officials, in the recent past the Fisheries Division has been involving stakeholders in the decision-making process; fishermen are becoming more involved and helping to guide the decisions of the FD; and there are education programs held by the FD and the Ministry of the Environment, to sensitize the public and create awareness about environmental issues and conservation of marine resources.

According to the FD, fishers are now being consulted, in particular for the implementation of new or modified gears. Fishermen are highly cooperative; they help to guide the management decisions, and are ultimately the ones who implement the projects or the new regulations. They are very conscious of the law and have a good understanding of conservation issues. Fishers often ask the FD to intervene to change the mesh size or size regulations in general to conserve the resources (e.g. minimum size for conch and lobster). Fishers would like the CITES restrictions to be lifted to open the export market for queen conch.

Records of stakeholder input in the decisions of the FD are rare, but in 2008 there were technical discussions to draft the Fishery Management Plan (Anon., 2008), which were followed by discussions with stakeholders (fishers, universities, tourism, etc.), with a good results.

FISHERIES MANAGEMENT

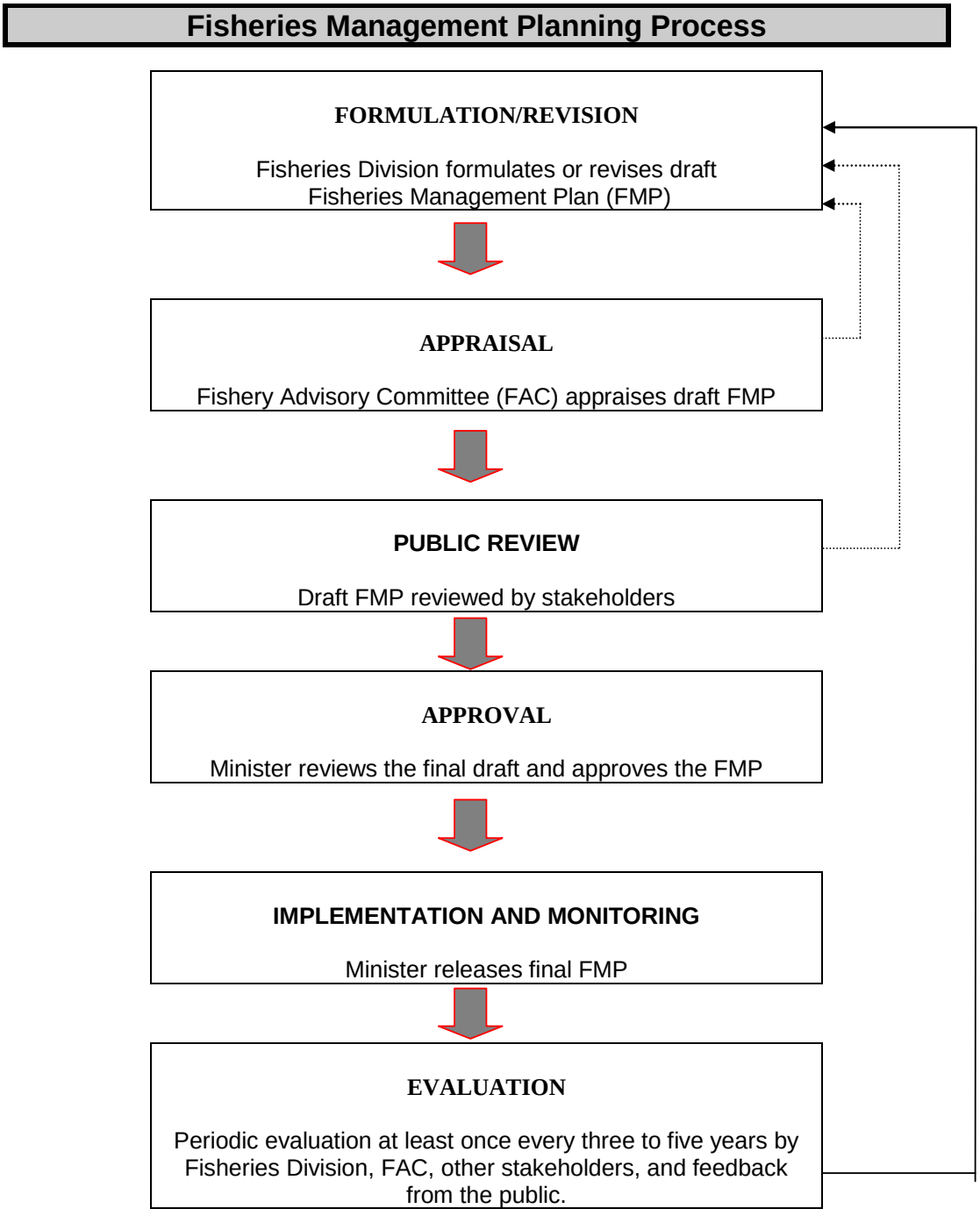

Figure 1. Proposed Fisheries Management Planning Process (Taken from Draft FMP, Anon., 2008).

Fishery Objectives

There are a number of general strategic objectives for fisheries management and development in Grenada, as provided in the Country Profiles of FAO (2007). There is a Fishery Management Plan, but it has not yet been endorsed. The draft Grenada Fishery Management Plan (Anon., 2008) lists the following as the overall objectives for fisheries management:

- To optimise the development of the fishery sector through effective management in order to create employment and stable sources of income for the fishers and the communities involved in fisheries and related activities.
- To optimise the amount of fish protein available for domestic consumption and export consistent with sound resource management practices.
- To optimise on the value of the limited fisheries resources through cost effective harvesting, value added processing and diversification of markets.
- To promote the image of fishing as an occupation that is socially desirable and financially rewarding.
- To maintain or restore populations of marine species at levels that can produce the optimum sustainable yield as qualified by relevant environmental and economic factors, taking into consideration relationships among species.
- To preserve rare or fragile ecosystems, as well as habitats and other ecologically sensitive areas, especially estuaries, mangroves, seagrass beds, and other spawning and nursery areas.
- To build and augment human resource capacity in order to support a more participatory approach to fisheries management.
- To promote the development of management strategies for the conservation and management of shared fish stocks.

The objectives for the queen conch fishery are also listed in the Draft Fishery Management Plan (Anon., 2008), namely:

- To maintain or rebuild the conch stocks at all times at a predetermined (still unknown) proportion of its mean unexploited level.
- To maintain and improve on the net incomes of the operators in the fishery at a level above the national minimum desired income.
- To include as many of the existing participants in the fishery as is possible given the biological, ecological and economic objectives listed above.

Finally, the draft FMP (Anon., 2008) also lists the goals of the Management Strategy:

- Enforce existing regulations.
- Establish target and limit reference points for the Fishery.
- Based on research, develop regulations to use such management tools as limited entry, prohibiting sale of immature conch, unshelled conch, closed seasons, and closed areas to protect the conch stocks. Precautionary measures, such as the prohibition of landing immature conch and the requirement to land conch in the shell can be developed without specific research.
- Promote participatory management.

In addition, the Chief Fisheries Officer noted that the Fisheries Division is interested in the sustainability of the conch industry, the livelihood of fishermen and the resource, with clear biological and socio-economic objectives. Also, the FD would like to improve the data collection system to conduct a proper assessment of the stock to comply with the CITES restrictions. It is very important for the government to comply with CITES restrictions and expand the conch exports to other markets, if this is possible.

Management Measures and Regulations

All Fisheries

One of the most important international agreements influencing fisheries management is the United Nations Convention on the Law of the Sea (UNCLOS) of 1982 (and its protocols). The UNCLOS process generated the Grenada Territorial Sea and Marine Boundaries Act of 1989.

Activities within the fisheries sector are managed by Legislations which include: The Fisheries Act, # 15 of 1986 and the Fisheries Regulations, SRO # 9 of 1987. In 1987 Grenada became part of the Organization of Eastern Caribbean States (OECS) Harmonized Laws.

In general the Fisheries Act and Regulations provides for the following: formulation and review of fisheries development and management plans; a co-management facility through a Fishery Advisory Committee; regional cooperation in fisheries and fisheries access agreement; local and foreign fishing operations; illegal fishing activities; control of fish processing and marketing operations; local management area and management measures; fisheries research and control of gear and methods for fishing; and grants rule making powers to the Minister responsible for Fisheries (FAO, 2007; Grenada Gazette 1996).

Other fisheries legislation includes: Fishing Vessel Safety Regulations (1990) – safety at sea; Amendment Regulations (1996, 2001) and Amendment Act (1999), Fish and Fishery Products Regulations (1999); and Marine Protected Area Regulations (2001); Beach Protection Act (1979) – sand mining; Land Development Control Act (1990) – coastal development; Town and Country Planning Act – controls use of coastal Zone; Power Craft Ordinance (1987) – controls operations of motorized vessels in near-shore zone (FAO, 2007; CRFM, 2009).

The draft Plan for Managing the Marine Fisheries of Grenada (Anon., 2008) discusses the Fisheries Management Planning Process; Coastal Zone Management Planning; Fisheries Legislation; Regional Fishing Agreements; Institutional Framework; Decision making Mechanisms; Fisheries Research and Monitoring; Fisheries Enforcement; and Registration and Licensing Systems. Also, in includes Fishery-Specific Management Plans for following fisheries: Large and Small Oceanic Pelagic Fisheries; Small Coastal Pelagic Fishery; Shallow Reef and Bank/ Deep Slope Fishery, Lobster Fishery; Conch Fishery; Seamoss; and Sea Urchin Fishery.

A new policy, The National Fisheries Policy for Grenada (stemming from ACP Fish II Policy, 2012) is currently under review and about to be implemented. The policy will be accompanied by an Action Plan for its implementation. It will provide a "road map" for the practical steps to make the policy effective.

The ACP Fish II Fisheries Policy for Grenada (2012) describes the context for the policy, covering the fish resource, the fisheries, the legislative basis, the Fisheries Division as an institution and Grenada's relevant international obligations. Key national priorities, the goals and objectives of the Fisheries Division are analyzed, as well as regional and international priorities and their implications. The policy covers five main themes:

- Enhancing the status and capability of fishers
- Sustainable stewardship & conservation of aquatic resources
- Realizing the development potential inherent within the fisheries sector.
- Maintaining the sector's role in sustaining livelihoods of the poor.
- Generating a positive interaction with Grenada's wider economic community.

Queen Conch Fishery

From the 2001 Fisheries Amendment Regulations, the fishery conservation measures for queen conch (*Strombus gigas)* are:

(1) No person shall take, sell or have in his possession any "immature conch".
(2) The Minister may declare any period as a closed season for conch.
(3) No person shall fish for conch during the period of the closed season.
(4) In the Regulation "immature conch" means
(a) a conch with a shell smaller than 18 centimetres (9¼ inches) in length; or
(b) a conch whose shell does not have a flared lip; or
(c) a conch with a total meat weight of less than 225 grams after the removal of the digestive gland.

There is a high uncertainty regarding the status of the queen conch stock, therefore the Biology Unit of the FD has recommended that the precautionary approach be used to manage this fishery. The precautionary approach is not formalized in the draft Fishery Management Plan (Anon., 2008). This includes maintaining current effort by not issuing new licences. Other management controls are also proposed or are applied, even if not included in the regulations (*Table 4*).

Table 4 Current management controls which are being applied.

Control	Strength/Weakness	Evaluation
No take of Immature Conch (Size Limits)	Shell regulation cannot be enforced for most of the fishery because shells are discarded at sea. Enforcement of meat weight also difficult, unless samples are taken at points of landing. Definition of "flared lip" imprecise.	Analysis of size composition data only included adults (CFMC/CRFM, 1999). Need new size composition to evaluate.
Closed Season	It is one of the harmonized regulations, but has not been implemented yet.	None
Closed Areas	Marine protected areas have been implemented, but they are small and shallow and do not protect conch directly. Some MPAs protect nursery areas (mangroves and seagrass beds), but <1% of conch habitat. In general, unless regularly patrolled, MPAs are difficult to enforce.	No surveys have been undertaken, but are needed to estimate abundance within and outside closed areas.
Effort Limit	Not in formal regulation, but it is implemented through licensing set at precautionary levels. It is very rare to get new applications for dive boats.	The number of divers is known and stable (approx. 45-50); dive effort is not increasing.

Subsidies
The Grenada government promotes heavy subsidies for fishermen. Bona fide fishermen (genuine fishermen in a particular district) are entitled to concessions for the boat, safety equipment, masks, but not for the gear. Concessions also include tax breaks of 10 to 20% or up to 100%, also on the fuel. The Fishery Division does not encourage concessions, particularly not on the gear. From the administrative perspective, limiting concessions automatically imposes a limit on effort.

Enforcement
The Fisheries Division has the primary enforcement role for domestic fisheries. The police are called upon to arrest violators. Fisheries are a relatively low priority for the Coast Guard which is relied upon for enforcement of illegal foreign fishing. Other activities such a drug enforcement which are subsidized by the U.S. government have a higher priority. The Coast Guard mainly responds to specific alerts related to fisheries. Illegal fishing by Venezuelan and American boats remains problematic. Local fishers are involved in surveillance-at-sea through a 'Coastal Watch' Program. Signing of the OECS Common Fisheries Surveillances Zones Agreement in 1991, improved regional cooperation between member states (Anon., 2007).

Very little information on enforcement was obtained during interviews. Enforcement activities also appear to be limited by the lack of resources and field officers. Conch fishermen perceive that there are more divers, and thus more competition for the resource and less compliance with the regulations, although generally, fishermen understand the importance of the size limit. There is also some suspicion of poaching from neighbouring islands.

Management Options
There are a number of options to achieving improvements in the management system of Grenada. Only those that may be feasible (financially and logistically) in the near future, that are being considered at the Fishery Division, and that were discussed during the site visit are included here, provided also in the form of detailed recommendations.

Harvest Strategy
A harvest strategy consists of various linked components, which, taken together, ensure sustainable harvest. The three components are harvest control rule, which limits catches, the information which the rule uses, and the decision-making process which applies the rule. Only some spare elements of the harvest strategy are present in the management system of Grenada, and they do not appear to be systematically linked. To re-design the whole management system, it is best to consider that the harvest strategy is just being developed, where the existing elements that are useful will be preserved. Thus, the first step will be the collection of appropriate information that will begin to feed the system and will lead to the next phases (assessment, development of HCR, development of appropriate management controls). Several specific recommendations for data collection are provided in the next section.

To be effective, any controls must limit or reduce catches. The only control really implemented for conch in Grenada is the size limit, which is based on the regional harmonized regulation, but not on any assessment of the size composition.

Currently, there is an unofficial decision rule to control the level of harvest, consisting of keeping the effort stable. It is a recommendation, not formally incorporated in the regulations. Also, there is currently no way to detect overfishing, but the catches, catch rates and the trends of the fishery in the south are used as indicators. The data are collected, but not used to provide formal management advice.

Effort limits may prove useful, but effort or catch limits cannot be applied empirically under the assumption that the current effort is sustainable. Trends in abundance are needed to determine the appropriate catch and effort levels, and also, how large the reduction in catch (and effort) should be. The larger the reduction in catch, the safer the fishery will be.

All controls should be evaluated, which will require an appropriate monitoring system. For this reason too, most of the recommendations in this report are targeted to the development of a better monitoring system.

Given the value and importance of Grenada fisheries, more resources need to be made available to the Fishery Division. Currently, several activities required in a complete management system are lacking (notably monitoring of total catch, abundance surveys, basic biological research, analysis of information, enforcement), while significant resources are spent in the routine collection and entry of incomplete data (only at primary landing sites- fish markets and processing plants that export product) that never gets analyzed. In summary, the Fishery Division currently lacks the capacity, primarily trained staff and the financial resources, to collect, analyze, and manage the information required for good fisheries management and to support field officers who can conduct regular patrols and enforce the law.

Decision-making Process

There are a few essential options to achieving improvements in management organisation in Grenada:

1. **Stakeholder participation in management:** The consultation process needs to strengthen the participation of all stakeholders involved in the fishery. Although there are fishing co-operatives, they are not sufficiently organized as to have representatives who can voice their interests when management decisions are made. Fisher organizations themselves need to be strengthened, so they can be heard as a group with common interests and goals. The process of forming a National Fisher Organization (NFO), supported through the Caribbean fisher Organization (CNFO), is well advanced and needs on-going support. Quoting the words of a conch fisherman who has been diving for more than 30 years: "Fishermen need EDUCATION and FEEDBACK from the Government, we need to have a voice, and know that we can be heard".

   Non-governmental organizations need to be reinforced in Grenada to provide conservation and management perspective to the management, and become important for education and outreach initiatives and the general public.

   The fishing community and other stakeholder groups such as universities, processors, and NGOs must be able to represent their views on management or contribute to decisions in a transparent way. It appears that the FD needs to encourage an organized representation of interest groups, by making the consultation process more open to all interested and affected parties.

2. **Education/ Capacity building:** There are at least three sectors that need to understand fisheries management. First, higher government officials/ decision-makers need to understand the importance of data, information, research, training, and capacity building to manage the country's fishery resources. This should lead to the provision of adequate resources for the required programs and staff at the Fishery Department and the Ministry of the Environment.

   The second sector are fisheries officers, data collectors, data-clerks, market enumerators, who need to understand the purpose and use of the data they collect, and why it needs to be accurate.
   The third sector includes fishermen and processors. In general, they are aware of the importance of conservation measures for the sustainability of fishery resources, and of the importance of complying with regulations to preserve both the resources and their livelihoods. This awareness needs to be reinforced continuously. Processors provide most data and are able to control fishing activity through

their purchasing. Processors and fishermen also need to be instructed on the importance of reporting to generate data that can be used to better guide management decisions.

A fourth sector is the general public, who need to be sensitized about environmental protection and conservation of marine resources. School children and high-school students would take priority.

All levels of government need to be involved in the development and funding of these education programs, but if non-governmental organizations acquired more strength, they could play a significant role in creating more and better education initiatives.

Information and Assessment

The basis for the decision-making is the information being collected. The available conch fishery information quantity and quality is poor. Poor information increases uncertainty and makes it particularly hard to reach agreement on difficult decisions, such as those limiting catches.

Catch data are incomplete and are a very significant source of uncertainty. Most fisheries science methods require complete catch data for any precise estimate of stock status. Unfortunately there is significant local consumption of conch which cannot be estimated. Some additional sampling and reporting is required to improve catch estimates.

One possible solution is to expand the monitoring program to secondary and tertiary landing sites. The FD considers that sampling each small market, restaurant and hotels may be cumbersome and inefficient, but supports the idea of collecting trip tickets directly from fishermen. There are only about 50 known divers who land conch at known locations (beaches or small landing sites). These people can be easily located and after an initial training period, they are likely to cooperate voluntarily. Additional fisheries staff would be required to visit landing sites and collect the data; the current staff is not sufficient to perform any additional duties. It is unlikely that fishermen will be able to fill out any forms or report their catch on their own, as many are illiterate. Thus, permanent fishery officers will be needed to monitor at all landing sites.

In addition, regular biological sampling could be incorporated into the monitoring programs. This would help to elucidate the size, age and sex structure of the catch and the stock. Fishermen could be trained again to participate in biological sampling, as they did in the mid-1990s.

There are no assessments of stock status, so there is no clear evidence that there has been a significant change in abundance. It is not known if the current stock is above or below precautionary limits. Reference points need to be set at a very precautionary level taking into account the data gaps. Estimation of the total catch is necessary to have a better estimate of how much the fishery is removing from the stock. Unfortunately, it is unlikely any precise determination of stock status will be available for some time.

There is, however, anecdotal evidence to imply management action should be taken to reduce exploitation significantly in traditional fishing areas. This could be argued as necessary under the precautionary approach to fisheries management.

Some form of stock assessment would be useful to determine the status of the current fished areas. Although costly, the fastest way to do it would be through well designed, stratified abundance surveys around the main fishing areas. Ideally, such surveys can be replicated. Fishermen could also be trained to sample, as they are the best divers who know the fishing grounds best.

It is also apparent that significant data useful for assessment and monitoring are collected, but are unavailable because the data management system is inefficient. Data needs to be computerised and

managed using software. Improvements can be made even using data table tools in Excel as well as developing a simple database.

There are very few fisheries research projects related to Grenadian fisheries that are conducted at local universities or in neighbouring countries. There is no budget for fisheries research at government agencies (specifically the Fishery Division). Some (personal) projects happen only due to the interest and self-motivation of the Biologists of the FD, but they do not receive any incentives to replicate or expand them, or to publish their results (e.g. through the CRFM scientific meeting), even if such research is necessary to answer some specific management questions. For example, a biologist at Grenville is currently estimating the average individual weights of conchs by sampling bags at the market himself. With no government funding or incentives of any kind, it is understandable that such projects lack any sort of continuity.

Research needs have clearly been identified by the FD. A proposal for an assessment of queen conch was drafted in 2007, mainly with the purpose of complying with CITES, but unfortunately was not executed due to lack of financial and human resources. The proposal included: biomass estimation, updating existing data, ground-truthing, sampling program, interviews with fishermen, estimation of CPUE, analysis of historical data, and so on. These are basically the main research activities that need to be undertaken to assess and manage the conch fishery. CRFM and Belize offered assistance with sampling. Between 2006 and 2008, consultants from the region carried out a training program, and CFRM assisted in the morphometric work with conch.

An Action Plan for the Conch Fishery (Table 5) was drafted in the draft FMP of 2008. It included the research needs for conch listed above, and also a census of the number of boats and fishers, of the main landing sites, production gaps in marketing, consulting with conch fishers, a biological survey in national fishing grounds, and data analysis. Unfortunately, the Action Plan for the Conch Fishery was not implemented.

It is very important that the original (2007) proposal and the ensuing Action Plan (2008) are revisited, with the additional recommendations from this and previous reviews of the data and the management system. These documents contain all the main activities that need to be undertaken for the Grenada FD to move forward in the management of the queen conch fishery.

A phased plan with clear objectives is required to move the fishery from its current position where monitoring, assessment and management have significant weaknesses, to one where there is a sustainable harvest strategy. A first step would be to draw the attention of government officials (such as the Minister of Agriculture and high-ranking officers who distribute the budget across government agencies) to the resources required for implementing an appropriate harvest strategy and the costs of not doing so. It is evident that even the most basic management options will require additional financial and human resources before they can be implemented.

Table 5. Action Plan for the Conch Fishery of Granada (reproduced from Draft Granada Queen Conch FMP, Anon., 2008)

Issues	Action	Implementation Strategy	Resources Required
Inadequate information on the stock level.	• Conduct visual underwater surveys.	• Undertake visual underwater survey. • Determine harvest and export quota levels. • Update and implement FMP.	• Funds, DOF as lead agency. Technical assistance from CRFM Secretariat and FAO.
Inadequate monitoring and reporting systems	• Improve on the monitoring and reporting systems.	• Review and refine catch, effort and biological data collection programme. • Improve on the monitoring and reporting systems for catch and export quotas to CITES. • Continue to participate in the CRFM Conch Working Group.	• Funds, DOF as lead agency. Technical assistance from CRFM Secretariat.
Inadequate information on the cost and earnings in the conch fishery.	• Determine the cost an earnings of the various operators in the fishery.	• Undertake cost and earnings studies in the fishery. • If possible, conduct bio- economic assessments and use the information to refine the management strategy to maintain and improve on the earnings of the operators in the fishery.	• Funds. DOF as lead agency; technical assistance from CRFM Secretariat and FAO.
Inadequate quality assurance and safety mechanisms.	• Improve on the public and private sector systems for quality assurance and safety	• Review the policy, legislative framework, inspectorate mechanisms, infrastructure, etc. as it relates to quality assurance and safety. • Develop and implement a plan to improve on the quality assurance and safety systems to provide wholesome products at the local and export levels.	• Funds. DOF as lead agency; technical assistance from CRFM Secretariat and FAO.

Specific Recommendations

A number have been made. These have not been prioritized and financial and other resources for their implementation have not been identified. The first task would be to develop a plan to implement these recommendations. This could be done by prioritizing the activities, identifying resources (including fisher involvement), securing administrative and logistical support and then developing the implementation plan.

Information

- Stake holder analysis to identify the range of stakeholders, including fishers, buyers, exporters and other interested parties. This is useful for consultation and for sampling design.
- Need a more structured sampling plan to obtain more accurate estimates of total landings.

- Improve data collection system (please see Medley, 2008 for more recommendations). The Grenadian FD is interested in improving data collection system, both for assessment of the resource and to comply with CITES and this is a high priority. The sample program design should consider the collection of data directly from fishers as the best option (particularly for the measurement of effort), rather than at various points of collection (markets, hotels, and restaurants), which would be tedious and difficult to accomplish. There are approximately 50 known fishers, with known location, which would facilitate sampling. It is important to engage fishers and they will likely be willing to collaborate voluntarily.
- The raising factor used to correct the catch needs to be revisited, on a species by species basis. The proportion of unreported conch landings can be estimated from direct interviews with fishermen. In the past, they have been very cooperative with all research projects conducted by the FD, and have expressed interest to collaborate in order to improve the knowledge base and the regulations for a number of fisheries.
- Grenada needs an automated data management system that adapts to the data needs of Grenada, that links trip data (TIP) to license and registration information (LRI), is more user-friendly, produces custom summaries, and can endure staff turnover.
- Entry of data into electronic forms should take place at the fish markets and processing facilities as a priority activity. This would allow data clerks to perform other duties at the FD. Electronic filing of daily logs would also would help to do real-time analyses. Currently, there are delays of months in data entry, and some data are never entered due to lack of staff and time.
- An automated data management system would release staff from data entry and manual analyses. This would also lead to a less error-prone system. Currently, there are multiple transfers from TIP data sheets into weekly sheets, into the Excel files, etc.
- It is necessary to update the vessel registration database, conduct a census, and match license and registration information with landings.

Assessment

- An abundance survey could be used to get an estimate of conch population abundance and density by area. Surveys have not been done to date. It would be useful to be able to replicate surveys periodically. Fishermen can be trained to carry out the survey transects. It is important to have an abundance estimate to comply with CITES requirement, which could take many years using other methods.
- A stock assessment is necessary. The FD routinely collects catch and effort data from primary landing sites (main fish markets). Effort measured as boat days covers multiple species and gears on a single trip, so it is not easy to quantify the amount of effort appropriate to each species on any particular fishing trip. In this case, specific diving information can be obtained.
- Dive trips catch multiple species, essentially lobster and queen conch, with only conch during the lobster closed season. On the other hand, dive effort could be sorted out considering that a maximum of 70 boats (with an average of 45-50) use diving, which usually target lobster more than conch, except during the lobster closed season (closed May 1st to August 31$^{st)}$, when they fish more conch. Conch is fished year round, with lower catches during open season for lobster and a peak from May to August.
- It is relatively straightforward to identify the boats and fishers who fish conch, thus the amount of effort targeted to each species could be separated.
- Revisit the proposal for the assessment of queen conch (drafted by the Biology Unit in 2007). It included: biomass estimation, updating existing data, ground-truthing, sampling program, interviews with fishermen, estimation of CPUE, analysis of historical data, etc.

Management

- The Biology Unit has recommended applying the precautionary approach in this fishery by reducing or limiting the fishing mortality. The conch fishery is suspected to be overfished since 1989, when effort was shifted effort from one area to another looking for productive grounds, and most of the conchs harvested were small.
- The precautionary approach should be formally defined and added to the FMP. This can be achieved through discussion with stakeholders.
- It has been recommended to limit effort. Currently, there are between 45-55 units (boats) that target conch/lobster, so, for example, effort could be capped to approximately 50 dive boats.
- The Fishery Division does not encourage concessions, and there are no concessions on the gear, which is another (administrative) strategy to limit the expansion of effort.
- The Biology Unit has recommended having seminars with data collectors, data entry staff, and fishermen so they understand the use of the data, the quality needed, and the importance of data for the assessment and management of the fishery. It is also important for data collectors and clerks to visit landing sites so they can get a sense of what they are entering.

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Appendix A to Annex 4: Preliminary Analyses

Introduction

The following preliminary analyses were carried out on the available data. Currently, the only standard monitoring carried out for all species are estimates of total commercial landings at the market complexes. While initiatives to collect additional data would be recommended, it is useful to consider options in data poor situations.

The objective of these analyses is not to provide scientific advice to management, but test how useful these data are for this purpose. A complete description of the analysis is not presented here, but this analysis was used to illustrate some of the problems and possible solutions, so that guidance can still be provided for management decisions. This has allowed more detailed recommendations to be made on future data collection and analyses.

Catch Only Data: Biomass Dynamics

A simple biomass dynamics model (Vasconcellos and Cochrane 2005) was fitted to the available catch and effort data using a Bayesian fitting method (CRFM 2006). This method only requires a catch time series, but in practice additional assumptions and information are require which can be provided through a Bayesian fit. The model depends upon an implicit bioeconomic model with fishing effort being attracted into and out of a fishery. This therefore requires in addition to biological assumptions, additional assumptions regarding reasonably constant economic conditions.

The model requires five parameters: an initial stock status (B_1), unexploited stock size (B_∞), an intrinsic rate of increase (r) and a rate of effort change (x) and a bioeconomic equilibrium (B_E), the point when fishing effort will remain constant. The model was fitted in an Excel Spreadsheet making use of the statistical software (R).

Data are very limited in this and many other small scale fisheries throughout the Caribbean. The data consist only of recorded landings (Fig. A.1), so options for analysis are limited. In this case, the data show a substantial decline 1988-1995, after which landings remained low until 2012. The model can only interpret the reduced landings as overexploitation, resulting in the diversion of fishing effort elsewhere and allowing the stock to recover. The decade or so before landings appear to increase again is consistent with expected biomass growth rates of conch, but otherwise there is little independent evidence to support this interpretation of the data. Alternative explanations for changes in recorded landings could relate to market availability, when specific orders might be made for conch product within markets, such as for export. The quantities of landings are very small (maximum is less than 16 t), and may therefore be subject as much to variation in demand as due to changes in catch rates.

While these results are preliminary, they merit further exploration. Information from stakeholders may help in the interpretation and hardening the assumptions. Another factor to consider is the dispersal of discrete grounds some of which may not have been fished for some time.

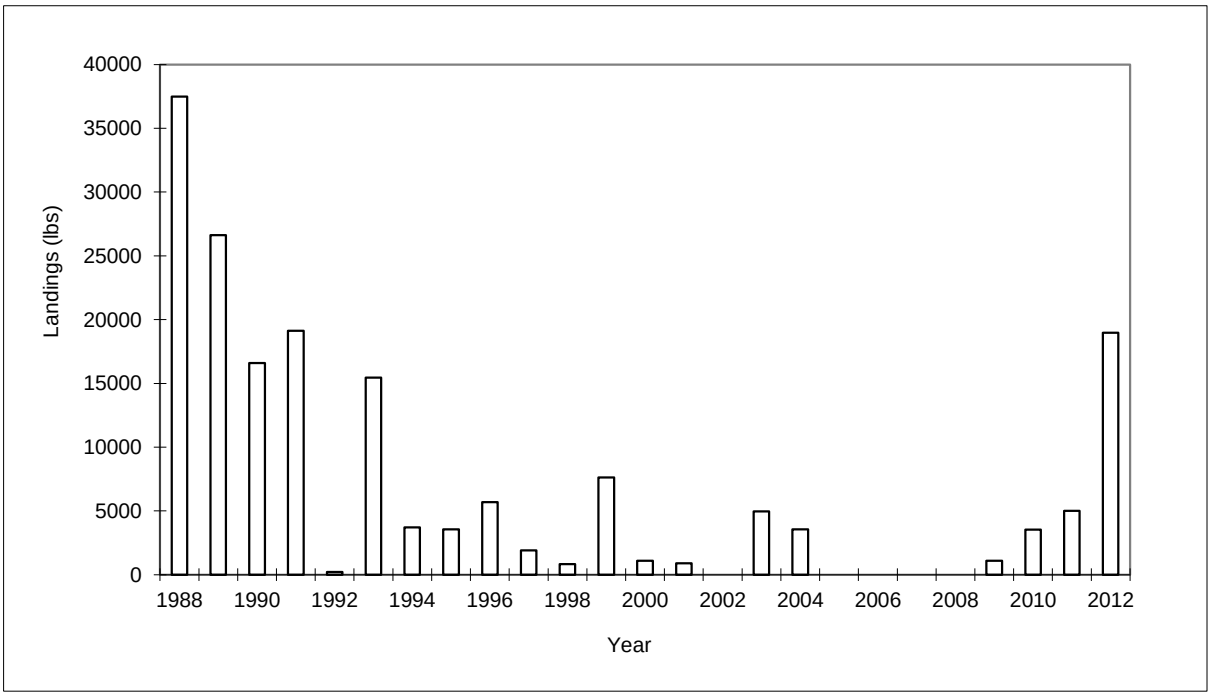

Figure A.1 Observed and expected landings to which the model is fitted to

The weaknesses in the data need to be considered in interpreting the results. All local landings that are not purchased through the market complexes are not recorded. Therefore any subsistence catches or purchases which bypass this system will not appear in the landings data, which in this case could be substantial. Other types of data such as catch and effort or size composition are not available. Such data would be useful to confirm results from the landings data alone.

To interpret the landings data, external information is required with well-judged assumptions. This can be achieved with the precautionary approach and expert judgement. Under the precautionary approach, it is appropriate to assume that the decline in landings is due to depletion unless evidence is obtained to the contrary. Other information required for the assessment were provided in the form of "priors", which are informative probability density functions describing likely values for particular parameters. These were provided in this case without review. A much better approach would be to apply a formal review process in their development to ensure they capture as much information as possible on their values. The priors used were:

- The initial state of the stock (β function with parameters μ=0.75, α=10: Fig. A.1) assumed that the stock was likely to be exploited to a limited degree, but not over exploited ($B_\infty > B_1 > B_{MSY}$).
- The bioeconomic equilibrium prior (β function with parameters μ=0.5, α=2: Fig. A.1) assumed that the equilibrium was unlikely to close to the unexploited or extinct state, but otherwise there was little information to inform on this parameter.
- The population intrinsic rate of increase (β function with range 0-2.0 and parameters μ=0.5, α=5: Fig. A.1) was set to be most likely in a range based on other stock assessments in the region (Medley and Ninnes 1999).
- The unexploited stock size (B_∞) prior was based on a log-normal (μ=11.219, σ=0.5, Fig. A.3) assuming a shelf area of 2237km^2 and 0.33lbs meat per hectare. The mean value is low, but it is not clear what proportion of the shelf is suitable conch habitat. The variance for the parameter makes the estimate reasonably informative, but would not prevent fairly large departures from this value if the data would indicate this.

- The intrinsic rate of change in fishing effort (x) prior was based on a log-normal (μ=log(0.5), σ=0.5, Fig. A.3). There was no strong justification for the prior in this case, but values are likely to be below 1.0. Alternative probably densities for this parameter should be developed.

As well as these priors, an additional assumption was made regarding the average unrecorded catch. No catch was recorded in a number of years, but it would seem unlikely that no catch was taken in these years. Therefore, the lowest catch recorded (214 lb) was added to all years to account for unrecorded catches. Clearly, better ways should be sought to deal with this issue.

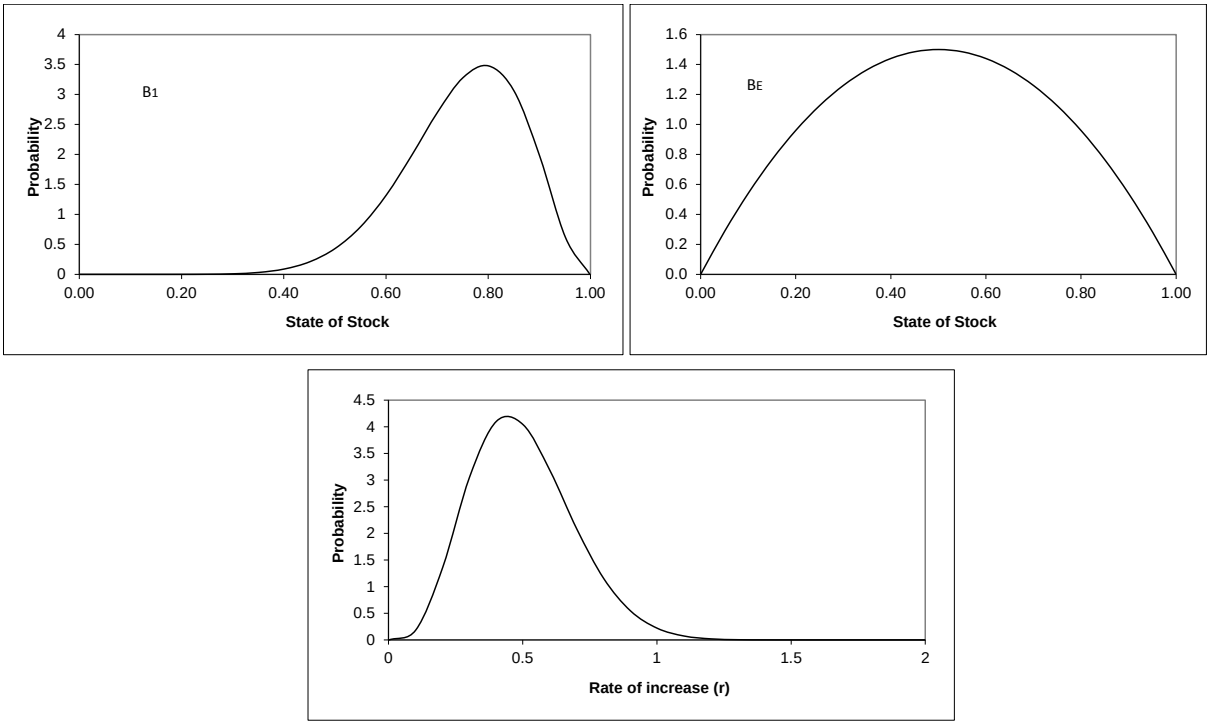

Figure A.2 Priors for initial stock size (B_1), bioeconomic equilibrium (B_E) and intrinsic rate of increase (r) based on beta function.

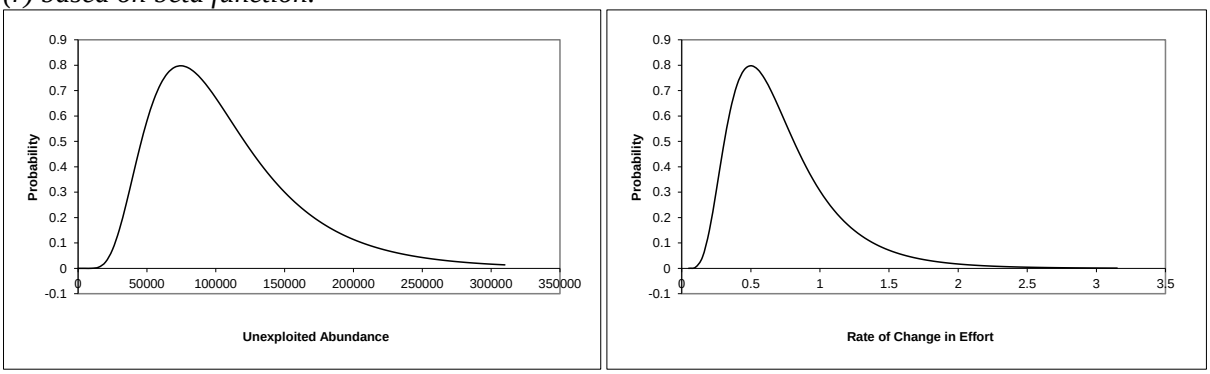

Figure A.3 Priors for unexploited stock size (B_∞) in pounds meat weight, and the effort rate of increase (x) based on the log-normal.

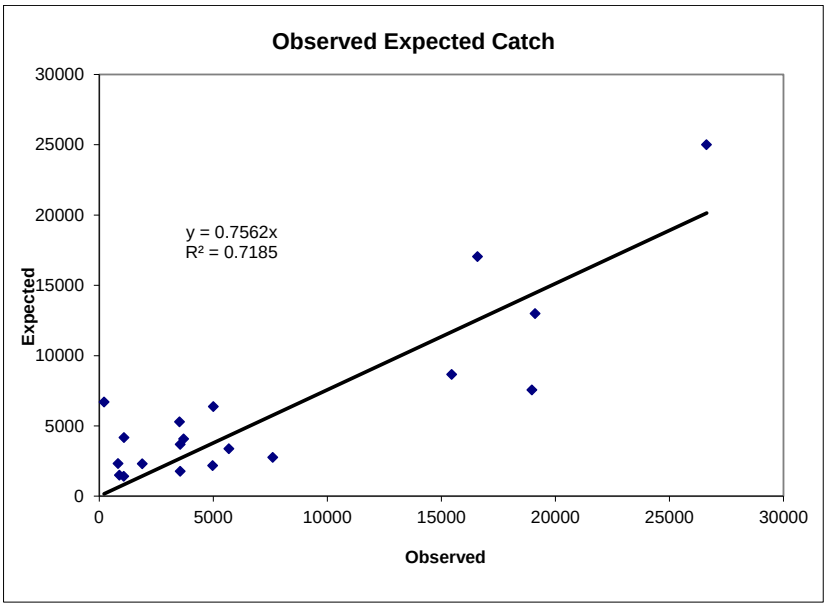

Figure A.4 Observed and expected catches, indicating the fit. The log-normal likelihood was used which should account for the heteroscedascity. However, there is significant bias at lower catches, most likely because recording of landings is incomplete.

Preliminary results suggest that the stock is fully exploited (Table A.1), with biomass around the MSY level ($B_t \approx B_{MSY}$), but fishing mortality higher than the MSY level ($F_t > F_{MSY}$) in 2012. However, these conclusions are based on very little information, and importantly, depend upon "priors" which are information supplied independent of the available data. Given the limitations of the data, the model fit to the catch data is reasonable (Fig. A.4). These results may only be used to illustrate the danger of an inadequate data system for a fishery that falls entirely under national management. In applying the precautionary approach, the fishery may need to be limited to very low levels, making a case for additional resource allocation to data collection.

Other similar analyses to the model applied here, such as the depletion-corrected average catch (MacCall, 2009) could equally well be applied. However, the Vasconcellos and Cochrane (2005) model potentially allows a smooth progression to using abundance indices and bioeconomic information should any such information become available, and could make better and more transparent use of regional information.

The underlying problem with the analysis is the interpretation of the data. Some catch data are missing and interpretation of the landings data requires scientific review. Other supporting information on catch rates, sizes and density would be very useful for this fishery, but not necessarily a priority.

Even assuming the data and their interpretation are broadly correct, there remains considerable uncertainty in the assessment. The result will always indicate levels of risk associated with particular management actions. The most obvious way to reduce risk is to reduce catch. Catches can be reduced directly (i.e. quotas) or indirectly through effort controls (e.g. closed season) or technical measures (e.g. minimum size).

Landings might be capped or limited to different levels to protect livelihoods and the resource. Allowing the current catches to continue without any control could lead to depletion and a large reduction in landings as has been observed previously. Deciding what is an appropriate landings limit requires a process which can lead to agreement among stakeholders. Part of this process should include scientific advice. Incorporating scientific advice might be achieved through projecting alternative catch limits

within the stock assessment model incorporating uncertainty (Fig. A.5). The stock assessment, while uncertain, can be used to test different catch limits to see how well the fishery might perform and the risks associated with different levels of landings. Progressive reductions reduce probability of overfishing, but may also reduce livelihood opportunities. Such information as this should be used as the basis for applying management controls to the fishery.

Table A.1 Parameter estimates from the biomass dynamics model

	Lower Percentile	**Median**	**Upper Percentile**
r	0.28	0.48	0.83
B_∞ (lb meat)	78528	99968	129620
B_{2012} (lb meat)	9000	47539	83426
MSY (lb meat)	8263	11925	18156
Yield in pounds (2012)		18975	
Replacement Yield (lb)	3875	10348	16620
B/B_{MSY}	0.19	0.96	1.47
F/F_{MSY}	0.89	1.61	5.32
B_E/B_{MSY}	0.35	0.95	1.82

Discussion

There are only two ways to deal with this sort of data poor situation in determining safe exploitation levels. Either analyses with expert judgement can be used, as presented here, or more data must be collected to carry out a full scientific assessment. While a full scientific assessment is desirable, the costs and potential delays before scientific advice can be obtained mean that the former approach, relying on expert judgement and ensuring advice is consistent with the available data combined, is the most likely to work in these situations.

Relying on expert judgement should not mean that the source of information and advice becomes unclear. Procedures should applied which make the source of information transparent, and ensure that it is based on the best scientific information available. The review should make decisions on the priors used (Fig. A.2 and A.3), how unrecorded landings might be included, and the alternative assumptions used to define a set of models which are fitted to the data. This can be achieved through an independent review process involving fisheries scientists, ecologists and fishers.

The review should define possible scenarios that bracket the uncertainty. This should provide, ideally, a set of simulation models to project possible harvest levels to test whether they are safe. The experts involved in this would primarily be scientists. Using the outputs from the review, it should be possible to develop, test and agree harvest control rules that meet policy requirements (precautionary approach), expectations of stakeholders and that can be enforced.

It is important to note that likely landings limits would not be necessarily very onerous as long as the fishery is well monitored. For example, in this case it is noticeable that landings have fluctuated widely, and this would suggest that a landings limit would prevent excessive landings but may not be needed each year. In particular, a landings limit set at the MSY level should result in average landings less than MSY, a result which should be monitored. If true, the landings limit could be set at levels above MSY, allowing the fishery to take more advantage of market opportunities while not undermining sustainability.

What is not acceptable is to apply no management on the basis that the scientific advice is poor. Part of a good management process is to ensure adequate data are collected to support the harvest strategy. Poor data collection should result in much lower harvest levels. This implies that Grenada must either improve its data collection to apply a limit to landings and exports to below past levels.

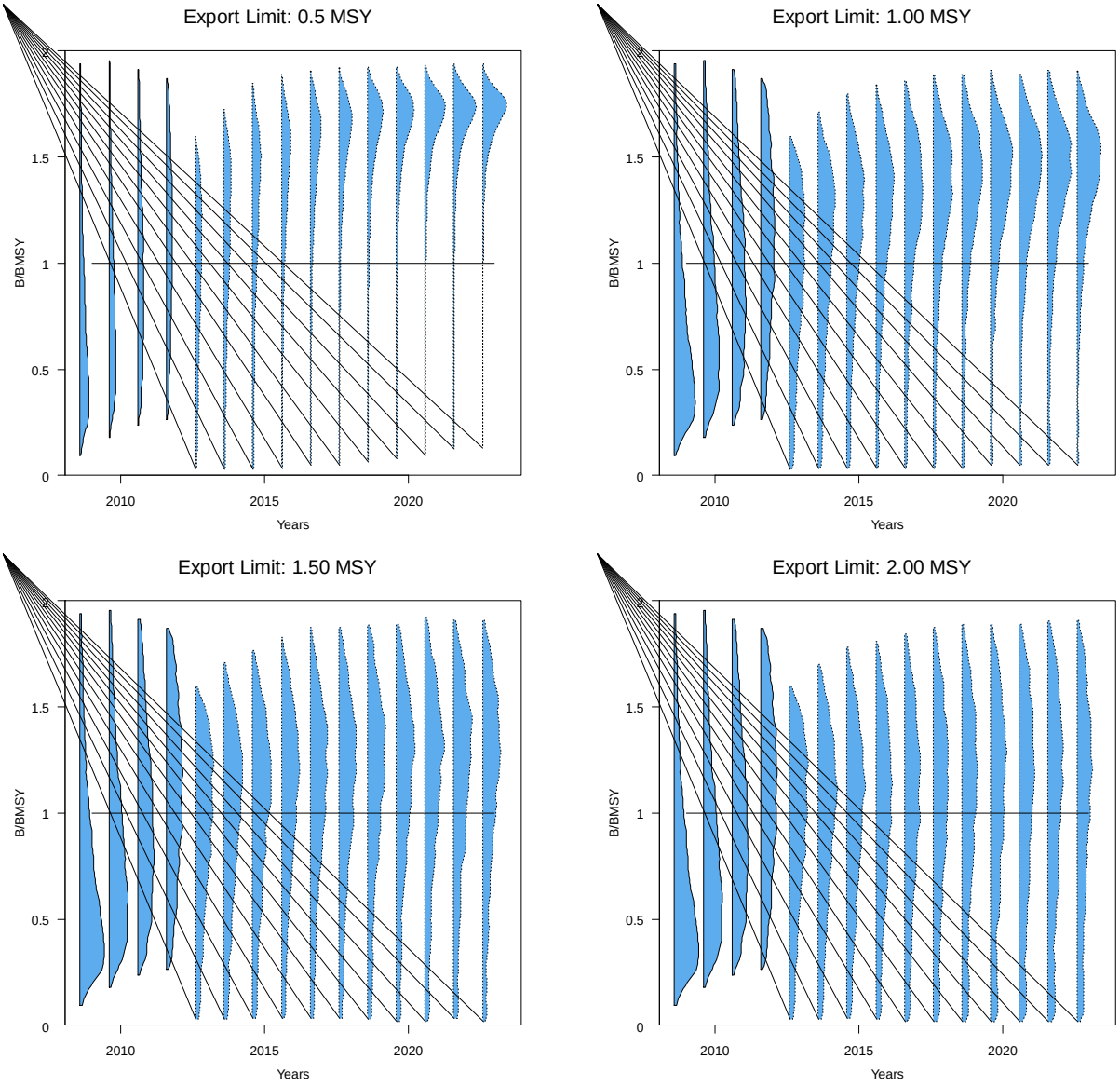

Figure A.5 Probability density functions for the projection of different biomass relative to biomass at MSY based on catch limits placed on reported landings based on the median MSY estimate (12000 lb). Flatter probabilities indicate greater uncertainty and probability mass below the horizontal line represents probability of overfishing.

Appendix B to Annex 4: List of people interviewed

The following people participated in the interviews and those marked with (*) provided most of the information on the fisheries management system and the current data collection in Grenada.

Name	Organization	Position
* Mr. Justin Rennie	Fisheries Division Ministry of Agriculture, Lands, Forestry and Fisheries	Chief Fisheries Officer Head of Statistical Unit
Mr. Johnson St. Louis	Fisheries Division	Chief Fisheries Officer Ag.
** Mr. Crafton J. Isaac	Fisheries Division	Fisheries Biologist
Mr. Frencis T. Calliste	Fisheries Division	Fisheries Officer
* Ms. Cherene Bowen	Fisheries Division	Data Entry Clerk
Mr. Paul E. Phillip	Coastal Zone Management Ministry of the Environment, Foreign Trade and Export Development	Senior Environmental Officer (previously Fisheries Biologist at the Fisheries Division)
Mr. Martin Simon	Calliste Fishermen Cooperative	President and Conch Fisherman
Mr. James Nicholas	Tuna export facility	President Southern Fishermen Association and Manager of South Processing facility

Appendix C to Annex 4: Main Activities Conducted
The case study involved a trip to Grenada March 24-29, 2013.

Date	Location	Main Activity
24 March	Arrive	
25 March	Fisheries Office Melville Street, St. George's	Meetings Mr C. Isaac & J. St Louis- Interviews & Management Checklist
26 March	Fisheries Office St George's	Meeting Mr C. Isaac (Biologist)- Interviews & Mgt. Checklist (cont.) Interviews included input from Mr. James Nicholas (President Southern Fishermen Association and Manager of South Processing facility for tuna)
27 March	Fisheries Office St. George's	Meetings w/ Chief Fisheries Officer- J. Rennie, Data Clerk- Ms. S. Bowen; Conducted Data review Interview with Mr. Martin Simon- Pres. Calliste Fishers Association (Diver- Conch-Lobster)
28 March	Fisheries Office St. George's Fisheries Office Grenville Field Trip	Meeting with Mr. Paul Phillip (Biologist, Ministry of Environment) Field trip to landing sites and markets (guided by Mr. St Louis): Woburn (South), Calliste & Grenville NE (market and main landing site) SICA Analysis with Mr. Calliste and Mr. Issac at Grenville office
29 March	Depart	

Appendix D to Annex 4: GRENADA - ACP Fish II Conch Fishery Information Checklist

The following notes are provided from interviews with the Fisheries Department staff, and information gained was used to inform the report. The notes presented contain information that are the views of local staff and include information beyond the scope of this study.

Stock Assessment and Management

Conch Management Issues	Main Questions	Response
Life History	Has there been any local research on conch life history and ecology?	Belize 1999, only once, Conch-Lobster subcommittee, biological parameters. Maturity/sex - objective was to find mortality Not all conch in all places are the same. Morphometrics done late 90's for Belize meeting. Univ. West Indies- CERMES- Post-graduate work in conch. Fishery Management Plan 2008 Draft- needs to be updated
Stock Structure	Is the conch within your waters treated as a separate management unit, or is the stock shared with other countries, or are there sub-populations that should be managed separately?	Can only be determined through DNA studies. Planktonic nature of larvae. Would have to focus on whole shelf as a management unit. Shelf- the Grenadine bank- from St Vincent to Grenada and a southern shelf- Usually split As a management unit only what is in their jurisdiction. No bilateral agreement, only through CRFM. One shelf- one population, but it's a question of leadership, at CRFM it can be raised- a joint management regime for lobsters and conch, could combine and standardize data and do one assessment for all territories. Each country needs to live up to their commitment- St Vincent has a whole string of islands, more complicated. Grenada only has Caricou.
Monitoring Data Types	Is the fishery routinely monitored and if so how is that carried out? How are the data managed and stored?	CFRAMP started TIP in the 1990s (Trip Interview Forms), then became daily log at fish markets./ Market staff completes the daily log, they should record every conch that is landed, by numbers or Total weight. Fishermen count it because they sell it by number. Organization- no data collectors. Need individual weights- need a sample and width- find Markets send weekly reports of their daily log. No analyses are carried out with the data. Sporadically other data is collected. Size- weight, one time effort. (Phillip St. Paul)

Abundance and Density Indices	Do you have an abundance index, for example based on CPUE or surveys?	Never any surveys. There is an ACP Fish 2 proposal - Also need routine data collection- most cost effective- to survey all the species. Reinforce existing routine data collection. Effort is not being entered electronically, but it is collected in the daily sheets, only recording production. Summary of landings is available, also trends in catches, not linked to effort. Catch trends due to seasonality. Raising factor- it has always been the same, but needs to be estimated properly. Currently 1.75 to 1.4 for large pelagics.
Catch Data	Are all catches recorded, or is there a significant catch which is unrecorded, such as subsistence and local landings? Are there any conch processors and do they report conch purchases or exports? Is there significant IUU fishing?	NO, significant proportion not recorded at all, because they are not brought to the primary landing sites: 1- market, 2- (secondary landing sites) beaches and 3- processors. Restaurants, hotels, many blind spots. They know where and what time they land and where, but no data collectors to go record the landings. About 15 landing sites, none on the west coast. No significant illegal fishing, but significant unreported fishing. Processors report exports, they need approval from the department. They export some, others freeze and sell to supermarkets. They have their own forms- only plants- data clerk visits them and extracts the data- primarily Tuna, they go every week. Inspection is done and certificate is issued. Conch is expoerted to Barbados and Trinidad. Fishermen don't keep a log, but they will tell you the landings. Need data collectors- as with CFRAMP (also check senior Manager for Coastal Zone)
Effort Data	Are you able to estimate or record fishing effort? If so, how is it measured?	Yes, it is recorded, but not entered, in hours fished, number of tanks.
Vessels and gear	Do you have information on the vessels that catch conch and their gear, such as might be held in a vessel register or licensing system?	Landings by boat by day by site. Conch may come from one boat or 2-3 boats. Interview – TIP needed- more accurate.

Management Strategy	How does the fishery management ensure the stock is not overfished?	It's a recommendation to apply the Precautionary approach. Suspicion that fishery overfished since 1989- shifted effort from an area to another area, conch were small. Recommend NOT to increase effort. Between 45-55 units (boats) that target conch/lobster- about 50 boats on average. Conch- fished year round- during open season for lobster, conch catches are lower. For lobster – closed 1st May to 31st August - then is when most conchs are fished. No scientific basis for status, based on observations. Cannot say it's fully exploited, no basis for action, need to do other studies. Problem in southern part of the island- between 7-10 years- also market driven. They stopped fishing in that area. Plastic bags- about 5 conchs in a bag, consumers didn't like it. About $20 per bag. Landing data is not observed. Limit effort, administrative thing- Fishermen get concessions for the boat, not for the gear. Fishermen can get concessions based on "bona fide" fishermen (genuine fishermen in a particular district). Bona fide fisherman is entitled to concessions- boat, safety equipment, masks. The Department does not encourage new fishermen. Concessions= tax break 10 to 20% up to 100%, also on fuel. Heavy subsidies for fishermen. Precautionary approach- not formalized in FMP- needs to be formalized with stakeholders.
Target and limit reference points	Do you have target and limit reference points set for the conch stock?	No, we don't know the status- cannot see if there are declines. Don't know if current stock is above or below limits. Reference points need to be set at a very precautionary level because of data gap (catches are not the total catch)- need to estimate total catch- need to fill data gaps. How much we're removing from the stock- need to estimate it.- not hard to determine. Grenada has no urge to export.
Harvest control rules	Do you use pre-defined decision rules to control the level of harvest?	Unofficial, keep effort stable (recommendation), not in the regulations formally.
Implementation of the harvest control rules	How do you control the level of harvest? How would the harvest be reduced if overfishing was detected?	Looking at catches, catch rates, the fishery in the south. There is no way to detect overfishing, not monitored. The data are collected, but NOT used.

Assessment and Analysis	What assessment and analyses are carried out on the available data (please provide any documents if possible)?	
Stock Assessment	Have you had a stock assessment completed? What method was used to assess the stock?	No assessments, except the tuna species done by ICCAT. CRFM meetings do assessments- dolphinfish, supply data to Scientific committee. Each country has to say what species is a priority to them, but you have to come with your data prepared.
Robustness of the assessment to uncertainties and assumptions	If you have an assessment, have the uncertainties and assumptions assessed? Are these uncertainties reflected in management advice?	No assessment, no assumptions. One assumption- uncertain of level of exploitation and status. Advice is to cap entry. Management measures are in place because of harmonized management. But no link between monitoring, assessment and management. Caps are based on the absence of an assessment. Models can take only so many assumptions.
Stock status relative to reference points and projections of HCR	Has the stock status been evaluated relative to reference points? Have the decision rules been tested to ensure they work and are precautionary?	No, assumed to be FULLY EXPLOITED-Overexploited taking juveniles (CRFM Special regional meeting 2004). No formal decision rules; there are no reference points.
Management Controls	For each management control that is applied, it would be useful to know whether their effectiveness has been evaluated.	
Area Closures	Are any areas closed to fishing conch? Have these areas, if any, been designed to protect part of the conch stock?	MPAs small and shallow, do not protect conch, one maybe lobster. No closed areas for conch, MPAs protect corals and associated ecosystems. Some protect nursery areas for different species. Some MPAS originally – seagrass beds and mangroves to protect nursery areas- post larval and juvenile phase, but MPAs are very small, not more than 1% of conch habitat.
Seasonal closure	Are there closed seasons for conch and if so when are they applied?	No closed seasons, has not been implemented yet, it's one of the harmonized regulations.
Effort Limit	What are the limits on fishing effort (licencing, number of fishermen, alternative livelihoods)?	Yes, licensing. Very rare to get applications for dive boats. Fishing license- multi-species fishery, but need to specify what form of gear. In the database you know which licenses are for diving.
Catch Limit	Is any sort of catch limit (quota) applied to conch?	No quotas for conch.

Sizes Limits	Is there a size limit (flared lip, shell length, lip thickness, meat weight)?	Yes, flared lip, shell length 18cm, 225g meat weight.
Bag limits	Is there a bag limit, and if so to which sector of the fishery does it apply (recreational, subsistence, commercial)?	NO bag limit. Fishing tournament for pelagics, and deep sea fishing. Only recreational fishing for conch might be the yachts (French from Martinique).
Other limits	Are any other limits or controls?	NO

Management System

Conch Management Issues	**Main Questions**	**Response**
Decision-making	How are decisions on fishery management made? Who is responsible for the different roles in decision-making (gathering information, giving scientific advice, making the final decision)? Who is involved in the decision-making process (advisory bodies, stakeholder consultation, Ministerial structures)?	See above – no formal system
Policy	Is there a policy document or fishery management plan, with clear objectives stated for the conch fishery? Does government policy include the precautionary approach?	See draft FMP
Review	Have there been any independent reviews of the management plan and/or scientific assessments?	No
Research Plan	Have you identified research needs necessary for the sustainable management of conch? Is there a research plan that identifies research objectives, activities and funding?	Yes, identified, last research needs articulated by Department- possibility of culturing scads to supply bait. Proposal for assessment of queen conch Proposal (2007) to determine biomass estimation, update existing data, ground-truthing, sampling program- interviews with fishermen, estimate CPUE, look at historical data. Need to revisit proposal- but not easy. 2008- Action plan: 1)- Review, look at number of boats and fishers, main landing sites, production gaps in the marketing. There was correspondence to CRFM and CITES to estimate biomass- CRFM offered assistance, also response from Belize- offered assistance in surveys.

		3) Consulting with conch fishers- done, 4) Biological survey in national grounds- no support, 5) First time CRFM agreed was 2001, they responded to request for assistance. CFRAMP project did morphometric work with conch. Heavy on training- consultants from the region did the training. About 2 years of sampling.
Compliance	Are fishers aware of the laws, regulations and sanctions? To what degree do fishers, including foreign fishers, comply with fishery regulations and laws? What enforcement is carried out? Are there incentives to fish sustainably (e.g. long term investment in the fishery, training and education, security of tenure, etc.)?	(President Southern Fishermen Association and Manager of South Processing facility, James Nicholas)- No involvement in the decision making process. CRFM is leading the charge, in Grenada not being able to influence the government. Represents about 20 tuna and large pelagics fishers. Back in the mid-1990s were deeply involved 1990- to 1995. Then government changed. ACP Fish II- Policy – necessary for years to come. National Fisheries Policy for Grenada. Compliance- fishers are not fully aware of regulations or consequences. Compliance is fairly good. Fishers- the commons, they don't fish too sustainably, they are not rewarded if they leave the fish there. But, some are aware, they have common sense, they have an idea, they have a concept of stock "you damage the CROP" (Crop= Stock) "if you overfish". Fishery officers not aware of code of conduct. Need to simplify Code of Conduct and distribute it to the fishermen. -Enforcement? All fishery officers are enforcement officers. MCS officer- now in training in Japan. Based on monitoring, you will know what controls, and through surveillance- Routine checks need to include primary, secondary landing sites, fish inspectors (exports, HSUP, quality control or undersized). Every shipment is inspected, primarily for quality and second for compliance. No incentive to fish sustainably, only punitive measures. Fishermen come and ask for regulations; problem is the tragedy of the commons. Fishermen need the FD to establish laws and regulations. They want to make a living now and in the

		future. Brooding stock in the West, untouched, shelf too narrow and deep, fishermen do not fish in that area.

Ecological impacts

Conch Management Issues	Main Questions	Response
Habitat	Has conch habitat (depth contours, biotopes etc.) been mapped? Is data on habitat held on a GIS? Are the main fishing areas mapped? Are there thought to be any significant impacts on habitat associated with the conch fishery?	NO, have not mapped habitat, know where seagrass beds are. They know the fishing areas, fishing grounds overlap with conch habitat. Yes, there is a GIS system-MARSIS (Grenadines Marine Resource & Space-Use Information System by CERMES) http://www.grenadinesmarsis.com/ Yes, habitat assessment- post-hurricane to see how well they have recovered- now 2 years- want to cover the East Coast.
Ecosystem	Is there any local research on the role of conch in the ecosystem? Has there been any ecosystem modelling (e.g. Ecopath) with conch as a trophic component? Is the conch fishery likely to be having any significant impact on the local ecosystem?	NO ecosystem model. ECOSIM for dolphinfish. Ecosystem impacts are unknown.

Appendix E to Annex 4: Grenada Fisheries Division- Daily Fish Landing Log

FISHERIES DIVISION - GRENADA																				
DAILY FISH LANDING LOG																				
LOCATION:	LANDING SITE:						TIME OF DATA COLLECTION:				START:				END:					
DATA COLLECTOR:	INTERVIEW DATE:																			
Boat Name:																				
Reg. No.																				
Boat Length:																				
Crew Size:																				
Area Fished:																				
Days Out/ Days Fished:	/		/		/		/		/		/		/		/		/		/	
Hours Fished:																				
Type of Gear Used:																				
Quantity of Gear:																				
Min. Depth / Max. DeptH	/		/		/		/		/		/		/		/		/		/	
Why Fishing was Terminated:																				
Species	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.	Qty (lbs)	Wt. Pr.
TOTAL																				
COMMENTS:																				

P.T.O.

Appendix F to Anex 4: Grenada Fisheries Division - Weekly Fish Landing Log

GRENADA FISHERIES DIVISION — WEEKLY FISH LANDING LOG

LANDING SITE:		DATE: FROM:				TO:			
COMMON NAMES	LOCAL NAMES	SUN	MON	TUE	WED	THUR	FRI	SAT	TOTAL
Yellow fin tuna	Turgeon								
Blackfin tuna	Blackfin tuna								
Skipjack tuna	Skip jack tuna								
Bullet tuna	Bullet tuna								
Frigate tuna	Frigate tuna								
Bigeye tuna	Bigeye tuna								
Northern bluefin tuna	Bluefin tuna								
Little tunny	Little tunny								
Atlantic bonito	Bonito								
Albacore	Albacore								
Great barracuda	Barracuda								
Common dolphin fish	Dolphin								
Pompano dolphin fish	Dolphin fish								
Spotted Sp. mackerel	Spanish mackerel								
Cero	Spanish mackerel								
Southern Sennet	Sennet								
Wahoo	King fish/ralay								
King mackerel	King fish/malata								
Atlantic sailfish	Ocean gar								
Blue marlin	Blue marlin								
White marlin	White marlin								
Sword fish	Sword fish								
Moon fish	Moon fish								
Round scad	Round robin								
Bigeye scad	Jacks								
Flying fish	Flying fish								
Keeltail needlefish	Long gar								
Jack	Cavalli								
Rainbow runner	Rainbow runner								
Ballyhoo Halfbeak	Ballyhoo								
Common snook	Snook								
False herring	Herring								
Atlantic thread herring	Herring								
Brazilian sardinella	Anchovie								
Shark	Shark								
Grouper	Grouper								
Snapper	Snapper								
Red hind	Hind								
Squirrel fish	Marryann								
Parrot fish	Cacabawi								
Sandtile fish	Whitening								
Grunt	Grunt								
Queen triggerfish	Boose								
Goat fish	Goat fish								
Doctor fish	Doctor fish								
Coney	Butter fish								
Conch	Lambie								
Lobster	Lobster								
Turtle	Turtle								
Sea urchin	Sea eggs								
Squid	Squid								
MARKET CLERK:							TOTAL		
COMMENTS:									

Annex 5: Haiti Case Study

Introduction

The purpose of this assignment is to provide Technical Assistance to improve and harmonize the scientific approaches required to support sustainable management of queen conch (*Strombus gigas*) by CARIFORUM States, and to present options for incorporation of the scientific information into effective management strategies.

This is a National Case Study report for Haiti. Although there was an intention to complete a site visit to Haiti, this was not possible. Therefore this report depends upon information from the Haiti participant at a CRFM conch management validation workshop in June 2013 (CRFM, 2013) summarised in Appendix A. Information on the Haiti conch fisher remains limited.

In general, the fishery management system in Haiti has not yet been developed. Therefore, this report focuses more on how good management procedures might be put in place rather than describe the current situation. The management issues addressed are those required specifically to conch following good fisheries management practice outlined in the FAO Code of Conduct and FAO Manual for the Monitoring and Management of Queen Conch.

Harvest Strategy Development

Overview

Four components are required for an effective harvest strategy. These are a data collection system, an analysis to convert data to information, a decision-making process to decide upon management measures and actions and, finally, the controls that the management applies to keep fishing at sustainable levels.
In general, a less rigorous system is needed at lower exploitation levels. However, in the case of Haiti, it is likely that the system will need to maintain careful monitoring of, and apply exact control over, the exploitation of its resources. This can be achieved, but would need to be developed so that the costs of such a system remain affordable.

A fisheries census in 1995 estimated that the number of fulltime fishers was around 9 300, with over 4 000 small boats and vessels (JICA 2011). However, a more recent survey of fishers in 2004 identified and interviewed 2243 fishers, of whom 626 (39%) reporting catching conch. Three different types of vessels are used by Haitian fishers: rowboats (canots à quille) from 3.3m to 6 m (10-18 feet) in length; flat-bottomed boats (corallins) from 3.3 m – 5 m (10-15 feet) in length, and dugout wooden boats (pirogues monoxyles) that are 3.3 m – 4 m (10-12 feet) long on average.

If the findings of the abundance surveys that have been conducted are confirmed (Wood 2010), the conch stocks will require rebuilding. This would need to reduce catches and income to the conch fisheries in the short term. However, the findings also suggested that recruitment remains strong, so such rebuilding should be reasonably rapid. However, Wood (2010) also indicated that habitat loss due to sedimentation may have contributed to reduced population size inshore, which would not be rebuilt through reduced fishing alone.

Data Collection

There are two sources of information on the status of the fishery: fishery independent visual abundance surveys and fishery dependent report and survey data. In general, fisheries cannot be managed effectively without good fishery dependent information, particular the total catch (all conch mortality caused by fishing).

Total catch will be difficult to estimate without conducting random sampling of landing sites through a trip interview programme. This would produce catch, effort and size/sex/maturity composition (if catches were sampled), and would cover all landed species. Around 10 new additional staff would be required, however, to cover all landing sites, but initial focus could be placed on the main conch fishery areas (CRFM, 2004). Furthermore, trip interviews might be designed to cover only catches not reported by processors or buyers, significantly reducing the amount of sampling required.

Higher priority should be given to improve reporting from industry wherever possible. Data can be obtained from industry at low costs and such data collection systems often prove sustainable. For example, reporting from processors should be made mandatory if they have an export licence. Such mandatory reporting can be extended to agents (buyers) and markets. Market sampling may also be implemented as this is logistically much simpler than sampling landing sites. Such reporting would not cover all catches, but should cover a significant proportion and should allow better estimates of catch and biological sampling. Data should, wherever possible, be reported in computerized form and not on paper.

Visual abundance surveys provide a way to get stock size information very quickly. However, by themselves, they are not adequate for a sustainable harvest strategy unless conducted frequently. This may be an expensive option, although if reliable fishery data cannot be obtained, it may be the only option.

Some sort of management of data by the fisheries department will be required. In the first instance, basic data management can be carried out in spreadsheets as "flat file" tables using appropriate utilities available, for example, in MS Excel.

Analysis

Even if a successful data collection system is initiated, it may be some time before a full stock assessment can be completed. Generally, population dynamics models need a long time series of data (> 5 years). However, shorter time series might be used if employed in conjunction with an "operating" model which can be used to apply best scientific knowledge and expert judgement in an assessment. An "operating" simulation model can use all current biological information on conch growth and mortality to improve estimation of stock status. This can be further improved if a visual abundance survey is conducted. A visual abundance survey provides an accurate estimate of current abundance and stock structure which can be used alongside fishery dependent information to estimate various values of interest in providing scientific advice.

Decision-making

Harvest control rules should be developed based on the collected data, analysis and consultation with stakeholders. Well defined rules are decisions that are agreed in advance so that management actions are timely. Because rules can be based on measures that are meaningful to fishers, such as catch rate, they provide a good basis for co-management.

Co-management decision-making will also require a management group representing stakeholders (fishers, scientists and government). The group should be tasked with overseeing the harvest control rule and other management actions, evaluating the performance of the harvest strategy and adjusting the system based on that evaluation.

Controls

Options for management controls are limited. Cost of implementation and enforcement are significant issues for Haiti. The following controls can be considered:

- Effort limit: Establishing a licencing system for fishers is usually a pre-requisite for good fisheries management. This might proceed through different stages: 1) fishing surveys to establish

numbers of fishers (CRFM 2004); 2) fisher registration; 3) annual licensing; 4) eventually leading to limited entry. Surveys of fishing vessels and fishers have been conducted, so a register of fishers and other stakeholders in the fishery (name, date of birth, contact information and role in the fishery) would be the next step.

- Minimum size: Appropriate minimum sizes could be set for both shells and meat weight based on selectivity, maturity and growth.
- Closed seasons: Closed seasons are generally easy to enforce and reduce fishing effort directed at conch. They may also protect conch during its spawning periods. A closed season is already in place, but monitoring is required to ensure that it is enforced.
- Closed areas: Closed areas are useful tools to protect habitat and those components of the conch stock that require particular protection, such as juveniles or spawning aggregations. Closed areas are difficult to enforce and they would therefore need to be agreed with fishers. Without spatial information on the distribution of conch, placement of effective closed areas may be difficult.
- Managed access areas: This approach may include closed areas, but primarily controls access to particular areas, effectively transferring rites for exploitation to local communities. If this can be implemented, it can work well in promoting community ownership of resources, which helps promote sustainable use. The technique is being successfully used in Belize.
- Export quota: If the export moratorium is successfully lifted, it should be under an export quota. This would prevent excessive exporting of conch on lifting of the export ban and allow the fishery management system to maintain control.
- Gear restrictions: The only possible gear control that would significant impact fishing conch would be to prohibit hookah and scuba. It has been reported that compressed air is increasingly being used. Banning compressed air would prevent fishers exploiting deeper water which would protect a proportion of the stock. However, there would also be a socio-economic impact which would need to be considered.

Tasks

Given the lack of development of a harvest strategy in Haiti, there is an opportunity to set up a harvest strategy for conch (and other fisheries) that applies best practice from the start. There are a number of tasks that must be completed to achieve this. While these task can be identified (Table 2), the precise activities that are require to achieve each one are unclear in most cases. Nevertheless, it is highly likely that each can be completed in some form, leading to an appropriate harvest strategy. Once such a strategy was implemented, it could be demonstrated that the fishery would no longer be detrimental to the conch species and the export ban might be lifted.

It is critical that any harvest strategy be sustainable, not only in the sense that the stocks will be conserved, but also in that the human and financial resources necessary to implement the strategy remain available in the long term. In Haiti this will be difficult to achieve, but is most likely to succeed through adopting a co-management system (JICA 2011). Co-management systems take longer to implement, but achieve greater levels of compliance at lower cost and would promote long term effectiveness of the harvest strategy.

Table 2 Activities and outcomes for developing a harvest strategy for the Haiti conch fishery.

	Task	**Outcome**
1	Formally adopt management principles and objectives which will allow scientific advice to be given and which will guide decision-making.	Maximum sustainable yield and precautionary approach should be included as main principles and objectives for fishery management.

	Task	Outcome
2	Develop a process through which principles and policy objectives will be obtained.	A management working group should be created with appropriate powers to implement policy and undertake activities outlined below. The working group would have representatives from all major stakeholder groups. The working group would have terms of reference based on policy and principles defined in Task 1.
3	Define management units	Although the conch resource could be treated as a single stock, it would be worth considering more than one conch management area based on fishing grounds. There are two main areas which could be managed separately with co-operation from the fisher communities.
4	Generate indicators of stock status	Reliable measures of conch total catch, CPUE and mean size should be developed. Indices of CPUE and mean size (meat weight) might be obtained from the processors at little cost. Improvements and extensions to this information might be obtained by extending data collection to the Port au Prince market, to agents who purchase conch from fishers and through development of a trip interview programme. This would improve CPUE and mean size (including shell metrics) data. Trip interview sampling and agents purchase records would likely be necessary to get complete information on total catch.
5	Adopt clear target and limit reference points for indicators	The working group should endorse MSY based reference points for indicators estimated from best scientific research available. Once the monitoring programme is complete, it will still take a number of years to have enough data to complete a stock assessment. Other methods would be needed to define appropriate reference points more rapidly. These could include a comprehensive visual survey, fishing experiments, and appropriate computer modelling drawing on the experience in other countries.
6	Consider future scientific research to inform management.	Develop a short to medium term scientific research plan necessary for good management. Research would depend on resources available, but fishers could be employed in various scientific activities during the period fishing might be reduced. Priority should be given to improving estimates of parameters important to managing the stocks, such as observed densities in fishing grounds, catchability and selectivity, conch distribution and indices of recruitment.
7	Develop a harvest control rule with stakeholders	Design measures to maintain the stock at or above MSY and additional actions which would be taken to reduce harvest should the stock fall below the target level (a rebuilding plan). This should be based upon available data, but developed with the agreement of fishers. Fisher interviews and meetings can be used to achieve this. Measures to maintain the exploitation rate at an appropriate level could include the closed season, gear restrictions (e.g. no compressed air use), limits on effort or catch (e.g. licencing or processor quotas), zonation and/or size limits. Rebuilding would require temporary reductions in catch to allow the stock to rebuild. Planning for this will be critical because

	Task	Outcome
		rebuilding may be the first management action required for the fisheries.
8	An enforcement plan needs to be developed.	Enforcement officers are required, but compliance is likely to rely on obtaining fishing community agreement with the measures applied. This can only be achieved with various outreach and educational activities. A register of stakeholders in the fishery would be a useful pre-requisite to developing any plan.
9	Complete a management plan defining the management process being implemented.	A fishery management plan should be agreed defining current management systems, information on the stock and decision-making processes as outlined in the tasks 1-8 above. A draft plan has been written for WECAFC meeting in 2006, but this document needs to be further developed as suggested above and resources found to implement it.

Specific Recommendations

Given the difficulties faced by Haiti in governance and likely problems in implementing a harvest strategy, a new fishery management system is likely to be needed. Developing a new system will require an extensive project which should cover more than just the conch fishery. The tasks which would be required for conch are given in Table 2. These could be adapted to cover all Haiti fisheries, but sufficient resources would be required over 3-5 years to initiate the plan.

References

CRFM 2004. Fisheries Survey Conducted During 2003-2004. Unpublished data.

JICA 2011. Final Country Report: Haiti. Formulation of a Master Plan on Sustainable use of Fisheries Resources for Coastal Community Development in the Caribbean. Trevor Hamilton and Associates for IC Net.

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

Appendix A to Annex 5: Summary Information Stock Assessment and Management of Conch Fisheries in Haiti

Conch Management Issues	Main Questions	Response
Life History	Has there been any local research on conch life history and ecology?	Wood (2010) looking density and distribution. But otherwise nothing specific on biology in the Haitian stock is available.
Stock Structure	Is the conch within your waters treated as a separate management unit, or is the stock shared with other countries, or are there sub-populations that should be managed separately?	Most conch fishing takes place in two locations: Canal du Sud and Anse a Pitres, the latter being on the border with Dominican Republic. Juvenile conch found throughout shallow water.
Monitoring Data Types	Is the fishery routinely monitored and if so how is that carried out? How are the data managed and stored?	
Abundance and Density Indices	Do you have an abundance index, for example based on CPUE or surveys?	There is no abundance index. Visual surveys were carried out in 1999, but not specific to conch. CRFM data from 2003/4 on numbers of fishers. Smaller surveys have been conducted, but do not cover the stock (Wood 2010).
Catch Data	Are all catches recorded, or is there a significant catch which is unrecorded, such as subsistence and local landings? Are there any conch processors and do they report conch purchases or exports? Is there significant IUU fishing?	Landings which are sold to (4-5) processors are reported to the fisheries dept., but all other catches are unknown. Conch is also sold direct to consumers at markets on ice. Dried conch is not commonly available. Processors sell to city hotels and restaurant. No exports are currently, although it is possible there is some illegal exporting. In 2010 landings were estimated at 200t, but this estimate has not documented. Processor data are provided but not computerized. A permit to export would require that data be submitted to the fisheries department. Other non-recorded catches are significant. But IUU fishing probably not significant. There is a main market in Port au Prince which is central point for distribution and a fixed number of vendors who buy then sell on conch. A registration and reporting system could take advantage of these bottlenecks in the conch product distribution network.
Effort Data	Are you able to estimate or record fishing effort? If so, how is it measured?	Should be licensed but most don't have one due to a lack of government capacity. Number of fisher estimates only for all fishers. Conch effort unknown.

Vessels and gear	Do you have information on the vessels that catch conch and their gear, such as might be held in a vessel register or licensing system?	Conch are captured mainly by free diving, but also as bycatch in tangle nets. Scuba/hookah use is increasing.
Management Strategy	How does the fishery management ensure the stock is not overfished?	
Target and limit reference points	Do you have target and limit reference points set for the conch stock?	No
Harvest control rules	Do you use pre-defined decision rules to control the level of harvest?	No
Implementation of the harvest control rules	How do you control the level of harvest? How would the harvest be reduced if overfishing was detected?	There is no direct control on harvest. There are limited numbers of fishers and fishing by foreign fishers is not allowed. Landed conch should have a flared lip, but this is not enforced. However, conch are usually land with the shell on, so shell based regulations may be possible. There is no available measure which can be used to reduce the amount of fishing. Co-management is being developed to develop controls and improve compliance through consultation and participation.
Assessment and Analysis	What assessment and analyses are carried out on the available data (please provide any documents if possible)?	
Stock Assessment	Have you had a stock assessment completed? What method was used to assess the stock?	No stock assessment
Robustness of the assessment to uncertainties and assumptions	If you have an assessment, have the uncertainties and assumptions assessed? Are these uncertainties reflected in management advice?	No
Stock status relative to reference points and projections of HCR	Has the stock status been evaluated relative to reference points? Have the decision rules been tested to ensure they work and are precautionary?	No

Management Controls	For each management control that is applied, it would be useful to know whether their effectiveness has been evaluated.	
Area Closures	Are any areas closed to fishing conch? Have these areas, if any, been designed to protect part of the conch stock?	No
Seasonal closure	Are there closed seasons for conch and if so when are they applied?	There is a closed season for conch April 1st to September 30, but it has not been enforced, so compliance is unknown. The closed season has not been evaluated.
Effort Limit	What are the limits on fishing effort (licencing, number of fishermen, alternative livelihoods)?	None
Catch Limit	Is any sort of catch limit (quota) applied to conch?	None
Sizes Limits	Is there a size limit (flared lip, shell length, lip thickness, meat weight)?	Prohibit capture of immature conch by setting limit on shell lip-thickness. This has not evaluated and has not be enforced, so compliance is unknown.
Bag limits	Is there a bag limit, and if so to which sector of the fishery does it apply (recreational, subsistence, commercial)?	None
Other limits	Are any other limits or controls?	Fishing conch with scuba, dynamite, compressor is prohibited. This has not evaluated and has not be enforced, so compliance is unknown.

Management System

Conch Management Issues	Main Questions	Response
Decision-making	How are decisions on fishery management made? Who is responsible for the different roles in decision-making (gathering information, giving scientific advice, making the final decision)? Who is involved in the decision-making process (advisory bodies, stakeholder consultation, Ministerial structures)?	Fisheries Division of Ministry of Agriculture to minister to executive. Fishing community consulted. Ad hoc advisory committee should meet monthly. In practice, need incentive of exports to be fully active.
Policy	Is there a policy document or fishery management plan, with clear objectives stated for the conch fishery? Does government policy include the precautionary approach?	Fishery development plan in 2010. Phased implementation due to a lack of resources. Written with consultation developed by Government and it follows the FAO Code of Conduct.
Review	Have there been any independent reviews of the management plan and/or scientific assessments?	No.
Research Plan	Have you identified research needs necessary for the sustainable management of conch? Is there a research plan that identifies research objectives, activities and funding?	Some research topics have been identified (Wood 2010, JICA 2011, CRFM 2004), but there is no overall research plan.
Compliance	Are fishers aware of the laws, regulations and sanctions? To what degree do fishers, including foreign fishers, comply with fishery regulations and laws? What enforcement is carried out? Are there incentives to fish sustainably (e.g. long term investment in the fishery, training and education, security of tenure etc.)?	General understanding of intent, not specific regulations. Compliance is thought to be poor. Enforcement is minimal. There are no prosecutions. Some self-enforcement in some communities may exist. There is no other incentive for compliance apart from community enforcement.

Ecological impacts

Conch Management Issues	Main Questions	Response
Habitat	Has conch habitat (depth contours, biotopes etc.) been mapped? Is data on habitat held on a GIS? Are the main fishing areas mapped? Are there thought to be any significant impacts on habitat associated with the conch fishery?	There has been some mapping, but not covering main conch grounds. The fisheries department does not have a GIS. There is some qualitative information from fishers on fishing grounds. Some trip interview information for other fisheries suggest 2-3 days per trip maximum. Average conch trips appear to be 7 hours (Wood 2010). There are shell middens, but no direct impact on habitat.
Ecosystem	Is there any local research on the role of conch in the ecosystem? Has there been any ecosystem modelling (e.g. Ecopath) with conch as a trophic component? Is the conch fishery likely to be having any significant impact on the local ecosystem?	There has been no local ecosystem research.

CRFM

The CRFM is an inter-governmental organisation whose mission is to "Promote and facilitate the responsible utilisation of the region's fisheries and other aquatic resources for the economic and social benefits of the current and future population of the region". The CRFM consists of three bodies – the Ministerial Council, the Caribbean Fisheries Forum and the CRFM Secretariat.

CRFM members are Anguilla, Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago and the Turks and Caicos Islands.