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CRFM Fishery Report - 2011

Volume 1

Report of Seventh Annual CRFM Scientific Meeting - St.Vincent and the Grenadines, 16-24 June, 2011

CRFM Secretariat
Belize
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Foreword

The Seventh Annual Scientific Meeting took place during 16 - 24 June 2011 in Kingstown, St. Vincent and the Grenadines. During this Meeting, CRFM Resource Working Groups examined data from the following fisheries: the flyingfish fishery of the Eastern Caribbean, the seabob fishery of Suriname, and the shrimp trawl fishery of Trinidad and Tobago and Venezuela. The SGWG also reviewed catch and effort data from the white shrimp fishery in Kingston Harbour, Jamaica. The LPWG conducted several activities: exploration of catch and effort data from the blackfin tuna fishery in St. Lucia, St. Vincent and the Grenadines and Trinidad and Tobago; review of a report on the fishing fleets targeting dolphinfish, flyingfishes and blackfin tuna in Martinique and Guadeloupe; review of a report on blackfin tuna catch, catch rates, and size structure from Venezuelan fisheries; and completed the first part of an ERAEF analysis of the Eastern Caribbean dolphinfish fishery. This year's CLWG meeting completed a peer review of a Caribbean spiny lobster stock assessment that was conducted intersessionally in The Bahamas during 2010. The RSWG did not meet in 2011.

A training seminar on bioeconomics of the ecosystem approach to fisheries was held during the meeting of the DMTWG. An update on the progress made by the JICA FAD and Statistics pilot studies, with special emphasis on the data collection, storage, and management aspects was also provided. A plenary session was held to review and discuss issues and recommendations pertaining to data, methods and training, as well as to review the inter-sessional activities of the DMTWG.

During the plenary session of the Seventh Annual Scientific Meeting, updates were provided on relevant collaborative activities/ projects/ programmes which included: the CIDA pelagic internship hosted by CRFM; the CLME project; the Regional Governance Framework Project; the CRFM/JICA Formulation of a Master Plan on Sustainable Use of Fisheries Resources for Coastal Community Development in the Eastern Caribbean Project; and the ACP Fish II Programme.

The Report of the Seventh Annual Scientific Meeting is published in two Volumes: Volume 1 contains the report of the plenary sessions and the full reports of the CRFM Resource Working Groups for 2011. Eight national reports were submitted for consideration by the Seventh Annual Scientific Meeting, and these are published as Supplement 1 to Volume 1. Volume 2 contains part A (Overview), and the fishery management advisory summaries of individual fishery reports comprising part B of each Working Group report, where relevant. Volume 1 is intended to serve as the primary reference for fishery assessment scientists, while Volume 2 is intended to serve as the main reference for managers and stakeholders.

The covers for this volume were designed and prepared by Mr. Shaun Young, while the photographs were provided by Ms. Maren Headley, Ms. Elaine Ferrier, Mr. Motoki Fujii and Ms. Brooke Campbell. These contributions are gratefully acknowledged.

Contents

List of Acronyms and Abbreviations

ACP	-	African, Caribbean and Pacific states
BRD	-	By-catch Reduction Device
CARICOM	-	Caribbean Community
CARIFIS	-	Caribbean Fisheries Information System
CERMES	-	Centre for Resource Management and Environmental Studies
CFF	-	Caribbean Fisheries Forum
CIDA	-	Canadian International Development Agency
CITES	-	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLME	-	Caribbean large Marine Ecosystem
CLWG	-	Conch and Lobster Resource Working Group
CNFO	-	Caribbean Network of National Fisherfolk Organizations
CPUE	-	Catch Per Unit of Effort
CRFM	-	Caribbean Regional Fisheries Mechanism
DMR	-	Department of Marine Resources
DMTWG	-	Data, Methods and Training Working Group
EAF	-	Ecosystem Approach to Fisheries
EBFM	-	Ecosystem Based Fisheries Management
EEZ	-	Exclusive Economic Zone
ERAEF	-	Ecological Risk Assessment for the Effects of Fishing
ETP	-	Endangered, Threatened and Protected (species)
EU	-	European Union
FAD	-	Fish Aggregating Device
FAO	-	Food and Agriculture Organization of the United Nations
FMP	-	Fisheries Management Plan
GDP	-	Gross Domestic Product
GEF	-	Global Environmental Fund
GLM	-	General Linear Models
HCR	-	Harvest Control Rule
ICCAT	-	International Commission for the Conservation of Atlantic Tunas
IFREMER	-	Institut Français de Recherche pour l'Exploitation de la Mer
IMA	-	Institute of Marine Affairs
IQ	-	Individual Quotas
IUCN	-	International Union for Conservation of Nature
IUU	-	Illegal, Unregulated and Unreported
JICA	-	Japanese International Cooperation Agency
LAPE	-	Lesser Antilles Pelagic Ecosystem
LPR	-	Limit Reference Point
LPWG	-	Large Pelagic Fish Resource Working Group
LRS	-	License and Registration System
MCA	-	Multi Criteria Analysis
MCMC	-	Monte Carlo Markov Chain
MPA	-	Marine Protected Areas

MSC P&C	-	Marine Stewardess Council Principles and Criteria
MSE	-	Management Strategy Evaluation
MSY	-	Maximum Sustainable Yield
NGO	-	Non-Governmental Organization
NMFS-SEFSC	-	National Marine Fisheries Service – South East Fisheries Science Center
NOAA	-	National Oceanic and Atmospheric Administration
NPV	-	Net Present Value
OSPESCA	-	Organization of Fishing and Aquaculture in Central America (Organización del Sector Pesquero y Acuícola de Centroamerica)
PDF	-	Probability Density Function
RGF	-	Regional Governance Framework
RSWG	-	Reef and Slope Fish Resource Working Group
SCPWG	-	Small Coastal Pelagic Fish Resource Working Group
SGWG	-	Shrimp and Groundfish Resource Working Group
SICA	-	Central American Integration System (Sistema de la Integracion Centroamericana)
SICA	-	Scale Intensity and Consequence Analysis
SSB	-	Spawning Stock Biomass
TAC	-	Total Allowable Catch
TCI	-	Turks and Caicos Islands
TIP	-	Trip Interview Programme
TRP	-	Target Reference Point
UK	-	United Kingdom
UNCLOS	-	United Nations Convention on the Law of the Sea
UNDP	-	United Nations Development Programme
USA	-	United States of America
UWI	-	University of the West Indies
VMS	-	Vessel Monitoring System
WECAFC	-	Western Central Atlantic Fishery Commission
WWF	-	World Wildlife Fund

PART I – Report and Proceedings of the Plenary Sessions

1. Opening of the meeting

A short ceremony was conducted to formally open the plenary session. Dr. Susan Singh-Renton of the CRFM Secretariat chaired the opening ceremony that began at 9:12 a.m. The ceremony commenced with the national anthem of St. Vincent and the Grenadines being sung by Miss. Trizanna Atkins. This was then followed by an opening prayer offered by Mrs. June Masters of the CRFM Secretariat.

Dr. Singh-Renton officially welcomed all the participants to the meeting. Noting the broad membership of the CRFM, and the need for coordinated management of one common marine space and the shared resources contained therein, Dr. Singh-Renton acknowledged the importance of the CRFM scientific meeting in bringing together fishery scientists, students and fish stock assessment experts from the CRFM membership, as well as from other countries, organizations and institutions within the region and across the globe. Some of these scientists and experts regularly attended the annual scientific meetings, and Dr. Singh-Renton noted her appreciation of their continued interest in CRFM's work, and welcomed their continuing contributions to this year's meeting.

The Honourable Minister in the Ministry of Agriculture, Rural Transformation, Forestry and Fisheries in St Vincent and the Grenadines, Mr. Montgomery Daniel, was unable to attend and to deliver the feature address as scheduled. In his absence, Mr. Nathaniel Williams, Permanent Secretary in the Ministry of Agriculture, Rural Transformation, Forestry and Fisheries, conveyed the Minister's regrets before welcoming all the participants. He affirmed that meetings such as this one are critical to sustainability of the livelihoods of our people. Reflecting on the global economic crisis and its impacts on St. Vincent and the Grenadines, Mr. Williams reminded the meeting of the importance of CRFM's mission to promote and facilitate the use of fisheries and other aquatic resources for the social and economic benefits of the present and future generations of Caribbean people.

Mr. Williams then noted that the scientific meeting was intended to address a range of fisheries management issues, ranging from bio-economic assessment to acquisition of the MSC label, and ecosystem-based management, and acknowledged the role of science in informing the management advice. In this regard, Mr. Williams urged efforts to ensure communication and full engagement with not only fisheries stakeholders, but also with other users of the marine environment, e.g. those using it for oil and gas exploration. The range of goods and services provided by the Caribbean Sea highlighted the need for establishment of an apex body for dealing with all issues pertaining to ocean and ocean resource management. He noted that the Caribbean Sea's resources were common property, and hence it was crucial that these resources be managed equitably.

In closing, Mr. Williams acknowledged the achievements of the annual scientific meetings to date, reminding participants that with more than 50 fisheries analyses completed, there was an urgent need for countries to respond actively to the management advice generated. Mr. Williams then expressed his hope that the outputs of this week would be disseminated adequately, and conveyed his wishes for a successful plenary session.

Mr. Milton Haughton, Deputy Executive Director of the CRFM, in his turn, offer remarks on behalf of the CRFM Secretariat. He extended a special welcome to participants from partner institutions, with a special mention of IFREMER Martinique, OSPESCA, the Nature Conservancy, Oriente University in Venezuela, the University of the West Indies (UWI-CERMES), National Marine Fisheries Service – South East Fisheries Science Center (NMFS SEFSC), Consultants Paul Medley (UK) and Professor Juan Carlos Seijo (Mexico), CIDA interns, the Permanent Secretary, and the Chief Fisheries Officer.

After providing a brief statement of the CRFM Secretariat's goal and purpose, Mr. Haughton emphasized the importance of the scientific meeting and the need for cooperative management of shared fishery resources. In this regard, Mr. Haughton noted that there was an indispensible need to understand stock status and to share statistics in a timely manner in support of developing the information base. He reminded participants that nations had a duty under UNCLOS and subsequent supporting documents to collaborate and to provide complete, accurate, verified, and detailed statistical information. He acknowledged that while agreeing on a standardized format for statistical reporting was difficult, continuing to work towards this objective was essential. Fisheries governance issues were currently being addressed under the CLME project. He brought to the participants' attention two major developments at the Ministerial policy / legislation level within CRFM over the past 11 months: the Castries (St. Lucia) Declaration on Illegal, Unreported and Unregulated (IUU) Fishing, and the adoption of a Caribbean Common Fisheries Policy. These two important and multilateral pieces of fisheries legislation had taken considerable time and effort to achieve, and were now in place for formal implementation. In closing, Mr. Haughton expressed his expectation of a rewarding day as the plenary considered the results of the various working group activities.

In conclusion to the meeting's opening, a Vote of Thanks was delivered by Dr. Singh-Renton to the Government of St. Vincent and the Grenadines, to the meeting speakers, to the rapporteurs, to the participating fisheries officers and consultants, to those participants of related organizations and institutions who provided inputs to Working Group deliberations, and to the CRFM Secretariat.

2. Adoption of Agenda

Mrs. Anginette Murray of the Fisheries Division, Ministry of Agriculture and Fisheries, Jamaica, served as the official Chairperson of the plenary session.

The Chairperson invited the meeting to review and adopt the agenda.

Regarding Item 5, Dr. Singh-Renton requested that the sub-items be presented in the following order: CLWG report, SCPWG report, SGWG report, and LPWG report. This modification was accepted by the Meeting.

The adopted meeting agenda is given in ***Appendix 1***.

3. Introduction of participants

The CRFM Secretariat advised that 12 CRFM Member States were participating in this year's scientific meeting sessions. Listed in alphabetic order, these 12 Member States were: Anguilla, The Bahamas, Barbados, Belize, Grenada, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

The following institutions and organizations were also attending in observer capacity. Some of these observers were participating in both working group and plenary meeting sessions: Organización del Sector Pesquero y Acuícola del Istmo Centroamericano (OSPESCA), National Marine Fisheries Service – South East Fisheries Science Center (NMFS SEFSC), IFREMER (Martinique), Instituto Oceanográfico – Universidad de Oriente (Venezuela); University of the West Indies (UWI-CERMES, Cave Hill Campus). An observer from the Nature Conservancy was in attendance for the plenary session.

In addition, two fish stock assessment consultants, three CIDA interns, and several CRFM Secretariat staff participated in several working group sessions and also the plenary session and provided specific technical contributions.

A list of participants is provided in ***Appendix 2***.

4. Presentation of national reports

The following countries, listed in alphabetical order, had submitted national reports prior to and during the 2011 scientific meeting: Belize, Grenada, Jamaica, Montserrat, St. Kitts (of St. Kitts and Nevis), and St. Lucia.

Dr. Singh-Renton urged those countries, which had not yet done so, to try to submit a national report as soon as possible for inclusion in the report of the meeting. It was pointed out that the data and information included in the national reports were very valuable to the work of the scientific meetings. National reports for 2011 would be valuable for informing the work of the 2012 and future meetings.

National reports submitted in 2011 are published in supplement 1 to Volume 1 of this report.

5. Reports of the CRFM Fishery Resource Working Groups

5.1 Conch and Lobster Working Group (CLWG)

The 2011 Chairperson and Rapporteur for the CLWG was Mr. Lester Gittens of the Department of Marine Resources in The Bahamas. Mr. Gittens presented the 2011 report of the CLWG. The detailed report of the CLWG is given in ***Appendix 3***.

Plenary discussion of CLWG report

Mr. Haughton sought clarification as to the status of the Bahamian spiny lobster stock and the recruitment information used in the assessment, given his knowledge of the limitations of the data. Mr. Gittens acknowledged that the data used in the assessment were not ideal but confirmed that the spiny lobster was not considered to be overfished. He explained that the recruitment information used in the assessment was taken from reports and recruitment studies in other countries. Mr. Haughton recommended that the linkages between the assessed stock status and the quality of the underlying data be more clearly made in the final report and asked for a list of the recruitment data references to be included in the final report. He also asked that a graph of catch trends be included in the final report and expressed his desire to see a greater emphasis placed on obtaining and improving scientific data in the Bahamas. Mr. Haughton also enquired about the evidence of resource sharing at the regional level, and Mr. Gittens indicated that while The Bahamas retains a lot of larvae, studies showed spread of larvae to countries such as the DR and Cuba.

Mr. Haughton also enquired as to why habitat studies had not been undertaken, given that it was known that casitas could have a negative effect on habitat. Mr. Gittens informed the meeting of a planned lobster study to be implemented in 2012. He noted that while The Bahamas recognized that habitat was a concern in respect of the use of casitas, this would not be addressed during the 2012 study.

Mr. Gongora (Belize) sought clarification as to whether there were any other gears used in the fishery in addition to casitas, stating that traps were used in Belize in addition to casitas and that they had found that this added a different dimension to habitat alteration issues. In a recent national survey, conducted in Belize with the assistance of OSPESCA, it was revealed that a significant number of traps were being used to catch spiny lobster (i.e. in the tens of thousands), and this was not previously appreciated. Mr. Gongora also said that a point to consider is the greater capacity for capture from trap fishers versus dive fishers. He also wanted to know if the Bahamas knew that casitas aggregated juveniles, as Belize had a problem with the illegal harvest of undersized juveniles relating to this gear type. In response, Mr. Gittens informed the Meeting that traps were used in the Bahamas but that the scale of these operations was believed to be small. Also, while compressors and hooks were used, the primary gear typed used to catch spiny lobster was casitas. The Bahamian fishery did not include diving operations. Mr. Gittens further explained that traps required licenses in the Bahamas but conceded that more traps could be used than were currently licensed. However, he did not believe this was a major problem. Ms. Gittens recognized that the harvest of juveniles could occur but that if Bahamian enforcement was working effectively, then this should not be a significant issue.

Mr. Haughton noted his support for the establishment of a limit reference point (LRP) for spawning stock biomass (SSB) but questioned whether there was understanding, agreement, and acceptance by the national managers and fishers regarding the practical meaning of the LRP, and the required response actions. Mr. Gittens explained that such discussions had begun and that there was good understanding by the industry's stakeholders. However, there remained disagreement about the response options, including the current proposal for incorporation of an export limit into the harvest control rule (HCR).

Mr. Haughton then highlighted the importance of the data improvement recommendation. Noting how crucial this was for improving the assessment process and the quality of the management advice generated, Mr. Haughton suggested that more emphasis be placed on this recommendation in the report. Additionally, Mr. Haughton requested that the deficiencies of the data used in the assessment be more strongly highlighted and also recommended the inclusion of a catch trends figure in the final report.

Professor Seijo noted that the Bahamas spiny lobster stock was a meta-population. Noting the decreasing dependence on the local spawning population with increasing latitude, Professor Seijo enquired about the consideration of management reference points that were directly related to recruitment. Dr. Medley responded that the HCR was dependent on the August catch rate, which in turn, was dependent on recruitment. Furthermore, the assessment adopted a working hypothesis that the Bahamas stock was not shared. The MSC aims were addressed by the proposed HCR, and it was recognized that the reference points should be linked to recruitment.

Professor Oxenford enquired as to what was being done to address the issue of poaching. Mr. Gittens replied that someone had been recently contracted to investigate the problem of poaching, and that IUU fishing appeared to be a significant problem. To this end, a Task Force, comprising a number of agencies, has been established to consider options for addressing the problem of IUU fishing. The timeline for addressing this issue by the Task Force was uncertain and Mr. Gittens advised that improved government support was necessary for it to be successful. However, he noted that US coast guard vessels had a large presence in the Bahamas, and this was expected to help reduce the instance of IUU fishing. Professor Oxenford recommended that the CLWG include these positive steps taken towards addressing Bahamian IUU fishing in their report. Like Mr. Haughton, Professor Oxenford urged that data gaps (e.g. recruitment, impacts of casitas on the environment, etc.) should be identified in the final report to provide guidance for addressing these data gaps in the future. Mr. Parker also supported this point, emphasizing the need to expand the data recommendation so as to make specific reference to the areas requiring improved data.

Ms. Ferrier enquired as to whether the red-list status of conch was taken into account during the assessment. Conch was not red-listed by the IUCN, but assuming that the reference concerned the CITES listing of queen conch in Appendix II, Mr. Gittens indicated that conch's status was recognized as an area of concern, and options for addressing the related issues had been discussed during previous meetings of the CLWG, but was not specifically considered in the current assessment. Mr. Phillips enquired as to whether there was a consultation-based management plan for the MSC certification. Mr. Gittens replied that processing plants needed the government's permission to export and that this therefore provided an opportunity for pursuing an export-based control rule. However, discussions were still ongoing, and there was no consensus yet on a way forward for management.

Dr. Singh-Renton enquired about the criteria applied for rationalizing the choice of the recruitment parameter 'borrowed' from the TCI, and modified. Dr. Medley explained that TCI productivity parameter was adopted because the TCI and Bahamas habitats were geographically, as well as geologically similar. It was also clarified that the productivity parameter was not modified, but a sensitivity analysis was conducted to consider the possibility of it being 70% less than adopted value. This was aimed at being precautionary. Dr. Singh-Renton also sought clarification about the spawning biomass pattern observed, and about the large confidence intervals of the distributions generated to predict future trends. Dr. Medley also explained that the assessment was undertaken using a semi age-structured model with mature and immature age classes because the available data were insufficient for further age classification. He explained that the spread of the confidence intervals was so great due to the increased uncertainty inherent in forecasts of the future and the use of random distributions for future (estimated) recruitment. He stated with emphasis that while he is very cautious about this assessment due to the poor quality of the data used, given the current information that the CLWG has at its disposal, there is no evidence to support that the stock is overfished. However, he further cautioned that this assessment outcome could change significantly were better data to be provided.

Dr. Singh-Renton expressed concern over the use and effectiveness of an HCR implemented without consensus and sought confirmation that the HCR was still in the proposal stage. Mr. Gittens confirmed that the current HCR was still being developed and that while currently unpopular, the industry had a strong desire for MSC certification and this meant that they would have to be cooperative to reach a workable compromise.

Dr. McConney asked whether market forecasts existed for spiny lobster as a link to the current stock management model. He also wanted to know what steps, if any, had been taken towards a co-management approach that included both government and fishers, among others. Mr. Gittens replied that Bahamian spiny lobster was exported to the USA, Japan, and Europe. These markets were specific and therefore influenced prices obtained for the product. Moreover, purchasing companies such as WalMart and Costco had made a pledge to move towards selling only MSC-certified fish, which was based on the FAO's Code of Conduct for Responsible Fisheries. This development was driving the current direction of the market. Although socio-economic issues had not been formally evaluated, it was pointed out that the MSC label would guarantee a good price for Bahamian spiny lobster. Mr. Gittens advised that the fishing sector contributed up to 3% of the Bahamian GDP and that recent declines in the international price of lobster had resulted in a notable reduction in fishing effort. There was thus an urgent need to diversify fisheries markets in the Bahamas to address this issue.

Mr. Haughton asked the Chair if the recommendations provided by the participants were to be agreed upon and included in the final reports of all Working Groups. The Chair asked the meeting if all CLWG recommendations were accepted. As there were no objections, all recommendations were adopted and the CLWG report was to be revised according to the adopted recommendations.

5.2 Small Coastal Pelagic Fish Resource Working Group (SCPWG)

The 2011 Chairperson and Rapporteur for the SCPWG was Ms. Maren Headley of the CRFM Secretariat. Ms. Headley presented the 2011 report of the SCPWG. The detailed report of the SCPWG is given in ***Appendix 4***.

Plenary discussion of SCPWG report

Mr. Gittens sought further information on the biology of flyingfish, specifically if they migrated and if their oceanic distribution was even. Ms. Headley responded that they did migrate. Professor Oxenford elaborated that in addition to being a migratory species, flyingfish had centres of aggregation, which were not well understood and changed from year to year. Additionally, she pointed out that the flyingfish have two spawning peaks. Professor Oxenford further explained that while it was currently believed that flyingfish in the Eastern Caribbean were all part of a single stock, this multiple spawning pattern may be indicative of the existence of more than one population.

Mr. Haughton enquired as to whether the SCPWG report contained any recommendations for management and conservation, and expressed confusion with respect to the clarity of the Working Group's management objectives. Ms. Headley responded that such recommendations, while not presented in this meeting, were to be included in the final report of the Working Group. Furthermore, Ms. Headley clarified that management objectives have been considered in guiding the assessment, and that Ms. Ferrier would be providing the specific explanations and details about this under agenda item 7.1.

Mr. Parker admitted that while he had yet to read over the SCPWG report in detail, he had strong concerns that Barbados' data were driving the analysis. He enquired as to the impact on the model and its outputs of not incorporating the data of other countries. Professor Seijo responded that the data used in the model were based on the regional data set used in the 2008 WECAFC assessment that included data from several of the range states. Mr. Haughton sought further clarification on the regional nature of the data and Professor Seijo clarified that while the data quality of the other nations could definitely be improved, the data set was indeed regional. He also emphasized that Barbadian catches were by far the largest out of all the model's contributing countries, and that this would be reflected in the model outputs.

Professor Oxenford provided further clarification on this matter by explaining that Barbados was the only country with a dataset extending back to the 1950s and that while data from all the other flyingfish countries were included in the model, the Barbadian data were used to test for major fluctuations and to set the model's periodicity. Ms. Headley added that a sensitivity analysis of the model would be included in the final report. In addition, Professor Oxenford stated that based on the 2008 assessment completed by the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, the flyingfish population was not in imminent danger. However, the 2011 bio-economic assessment indicated that this could change in the next 50 years if the fishery remained in open access and fishing effort continued to increase based on profits.

Mr. Haughton recommended that the Working Group's objectives and recommendations be clearly stated in the final report.

Dr. Singh-Renton enquired as to the status of the decision tables and Professor Seijo responded that work on the tables has begun and that once the draft versions of the tables were completed he could circulate these to the Working Group. He stated that the final version of the tables would be included in the final report.

Mr. Parker expressed confusion over the flyingfish fishery's percentage of profitability of 63%. Professor Seijo clarified that given the fishery's current level of access and effort, it was not operating at a bio-economically optimal level. Professor Oxenford clarified further by explaining that the economic model took into account the profits from other species caught during fishing operations, assuming fixed abundance of these species, but varying abundance of flyingfish. The model's profit output was therefore preliminary.

The Chair asked the meeting if all SCPWG recommendations be accepted and included in the final report. As there were no objections, the recommendations for revising the report were adopted.

5.3 Shrimp and Groundfish Resource Working Group (SGWG)

The 2011 Chairperson and Rapporteur for the SGWG was Ms. Lara Ferreira of the Fisheries Division, of the Ministry of Food Production, Land & Marine Affairs in Trinidad and Tobago. Ms. Ferreira led the presentation of the 2011 report of the SGWG, assisted by Mr. Ranjitsing Soekhradj of the Fisheries Department in Suriname, and Dr. Paul Medley, fish stock assessment consultant to the SGWG in 2011.

The detailed report of the SGWG is given in ***Appendix 5***.

Plenary discussion of SGWG report

No questions or recommendations were raised following the presentation by the SGWG and the Chair proceeded to the next agenda item.

5.4 Large Pelagic Fish Resource Working Group (LPWG)

The 2011 Chairperson and Rapporteur for the LPWG was Ms. Louanna Martin of the Fisheries Division of the Ministry of Food Production, Land & Marine Affairs in Trinidad and Tobago. Ms. Martin led the presentation of the 2011 report of the LPWG, assisted by Ms. Yvonne Edwin of the Fisheries Department of St. Lucia, and Ms. Lara Puetz, CIDA-intern, attached to the CRFM Secretariat during January - June 2011.

The detailed report of the LPWG is given in ***Appendix 6***.

Plenary discussion of LPWG report

Mr. Haughton sought clarification as to the criteria used to determine that the data provided by the Dominican Republic were of inadequate quality for inclusion in analyses completed by the Working Group. Dr. Singh-Renton clarified that the DR had supplied catch data only, and that the DR officials had expressed serious concerns about the reliability of the data. Mr. Haughton recommended that the final report contain a positive acknowledgement of the Dominican Republic's first efforts to submit data but also that it include an explanation of why the data were not used. Following this recommendation, Mr. Haughton also expressed his disagreement with the suggestion that the lack of accessibility of data by the Working Groups was linked to the CRFM not having an adequate mechanism for data sharing. He suggested that the underlying cause for this issue related to a lack of trust at the country-level that was not being addressed. He also recommended that rather than focus exclusively on recommendations aimed at improving science, the LPWG should increase emphasis on recommendations aimed at engaging managers and decision-makers, particularly government Ministers.

Dr. Singh-Renton clarified that the recommendation pertaining to data availability did not concern the issue of countries not sharing data, but instead it was a matter of one individual neglecting to submit the processed data and outputs of an assessment completed by an entire Working Group. She indicated that there was no prior rule established with regard to the responsibility of submitting data and other working group outputs with the Secretariat and recommended that such a rule be developed. She also explained that the LPWG's focus on scientific recommendations was because the 2011 meeting of this Working Group did not complete any assessment. However, she suggested that some of the existing recommendations could be re-phrased to better include decision-makers.

Mr. Haughton agreed that the commitment from the Working Groups and individual participants should increase and that responsibilities should be made clear from the meeting's outset. He also recommended that the LPWG group make recommendations on the state of the resource even if a full assessment had not been completed, as this would provide an avenue for requesting further assistance and considering available options for action.

The Chair asked the meeting if all LPWG recommendations be accepted and included in the final report. As there were no objections, the recommendations were adopted.

6. Report of the Second Meeting of the Working Group on Data, Methods and Training (DMTWG)

The 2011 Chairperson and Rapporteur for the DMTWG was Ms. Anginette Murray. Ms. Murray presented the report of the DMTWG, which is contained in ***Appendix 7***.

<u>*Plenary discussion of DMTWG report*</u>

Dr. Medley reminded the meeting participants that CARIFIS was a piece of software. He noted that what was important to retain was the CARIFIS data structure and data dictionary, as these would ensure that data were held in a consistent and harmonized manner regardless of changes in the database software used. Dr. Medley believed that CARIFIS had been burdened by the addition of too much complexity by some countries and proposed that unused data fields be removed to simplify the database. He stated that member nations should not be forced to use one single program if they did not want it and that there were a variety of freeware options for countries to use; however, he also stressed that maintaining the underlying and very useful structure of CARIFIS in new data repositories was essential. Meeting participants were also cautioned by Dr. Medley with regard training in the use of the R Statistical Software for assessment purposes without first identifying their routine data analysis and statistical needs. Dr. Medley explained that if R was not going to be used routinely for data analysis activities, then countries would continue to experience problems with using and understanding the software.

Mr. Haughton questioned whether an upgrade of CARIFIS was the best way forward given the cost and time commitment of such an action and the waning popularity of the software. He said that a data needs assessment may clarify whether resources were best put towards CARIFIS or other endeavours. Ms. Masters proposed that the current recommendation to evaluate training needs be expanded to consider routine data analysis needs, and this was supported. The Chairperson reminded the meeting also of the recommendation that the CRFM Secretariat employ a Database Manager. Dr. Singh-Renton clarified that the recommendation pertaining to the data manager acknowledged the need for more dedicated support in statistics and information at the CRFM level in general and not only for database management.

Mr. Haughton then reminded the meeting that all scientific meeting recommendations had to be presented and endorsed by the CFF and possibly also the Ministerial Council before being taken further by the CRFM Secretariat. He informed the DMTWG that the CRFM was about to undertake a review of its communications policy and that the addition of a new server could assist in improving the CRFM's data management capacity and address the current recommendations of the Working Group.

All DMTWG and plenary recommendations were considered to be accepted and adopted for inclusion in the final report. The Chairperson then closed agenda Item 6.

7. Relevant project and networking activity updates/reports

7.1 CIDA pelagic internship programme hosted by CRFM

CIDA intern, Ms. Elaine Ferrier, presented her work on the initiation of a Multi-criteria assessment of the flyingfish fisheries of the Eastern Caribbean.

Presentation summary

Regional governance of the Flyingfish fishery in the Eastern Caribbean requires agreement upon management objectives as well as how important these objectives are in relation to each other. A pre-established hierarchy of objectives can guide governance of the fishery and significantly assist decision-making processes. This hierarchy is critical to manage the complexity of a multi-species regional fishery, because it is rarely possible to optimize multiple and competing objectives (Pope 1997 as cited in Mardle *et al*. 2004).

Field work was conducted with fishers, fish processors, and fisheries division staff in Barbados and Tobago to determine their perception of the relative importance of a range of management objectives drawn from FMPs and reports relating to the Eastern Caribbean Flyingfish fishery. Thirty seven respondents from eight landing sites conducted a modified pairwise comparison technique (Simos 1990, as described in Ondrus and Pigneur 2006) which involved sorting cards with a description of each management objective. In this technique, respondents were asked to arrange the cards/ objectives according to their importance from 1 to *n*. This ordinal data was then converted into pairwise comparison tables. That is, if a respondent sorted card A as more important than card B, card A was recorded as being more important in the pairwise comparison. This assumed that by positioning a card in a certain level, the respondent believed this card to be more important than all those below it, less important than all those above it, and of equal importance to those in the same level.

During the study, the interviewees prioritized management objectives as follows:

16.2% Sustaining the stock size
- Ensuring that there are Flyingfish available for future generations
- Preventing overfishing to maintain a healthy stock

10% Accurate information
- Ensuring that an effective data collection system is in place to provide accurate information and knowledge about the state of the fishery

10.1% High profits
- Optimal economic benefits for all involved in the fishery

10.3% Effective management
- Ensuring that there is an effective system for management and enforcement to management as needed
- Effective management is adaptive, responsive to changing information about the fishery, and involves stakeholders in decision-making

7.4% Affordable food source
- Ensuring that Flyingfish remains an affordable and available source of food for the future

5.9% Fair access to fishing

- Fair and equitable access to fishing resources
- Minimal competition from other resource sectors

10% Successful processing and export market

- Developing the post-harvest production and export of Flyingfish

13.9% Habitat

- Minimal habitat degradation
- Minimal impact from pollution or other negative effects

7.6% Balanced ecosystem (balanced trophic levels)

- Balance in feeding relationships between predator and prey species

7% Resilience to environmental change

- Ability to withstand the effects of climate change, extreme weather events and other environmental changes

Plenary discussion

Mr. Haughton enquired if the regional dimension of cooperation was explored with the stakeholders. Ms. Ferrier responded that the subject of regional cooperation came up during her interviews but that it had not presented itself as a dominant issue. She explained that fishers were very supportive of regional cooperation on the whole, as long as the benefits were equal. At present, fishers in Tobago believed that Barbadian fishers benefited more from the fishery.

Professor Oxenford commented that the sample size for the study was small, and enquired whether there were plans to expand the analysis. She also expressed concern over the fishers' interpretation of the concept of 'habitat', given that some of the fisher responses included references to reefs and that flyingfish were not reef-based. Ms. Ferrier responded that the project could be expanded to include other countries in the future and could also be designed to include the solicitation of feedback. She was also initially surprised by the fisher responses to the habitat dimension of the interview but believed that the fisher responses and subsequent scoring were indicative of the fishers' more holistic view of the connectivity of ocean resources and environmental issues. She interpreted their inclusion of reef habitat degradation in the interview discussions as a way of indicating their awareness of broader oceanic degradation issues that would impact flyingfish health. Ms. Ferrier also believed that while many of the fishers externalized the impact of human activities on the fishery resource, this bias still served the purpose of highlighting their own potential role in these activities.

Mr. Heyliger stated that St. Kitts was considering the ecosystem-based approach to management and sought clarification about the participation of other countries in this fishery. He also asked if, given the underdevelopment of some flyingfish markets, whether dislocated fishers from other fisheries would be able to move into the flyingfish fishery. In response, Dr. Singh-Renton noted that St. Kitts and Nevis was located within the expected distribution of the Eastern Caribbean flyingfish resource. In accordance with international law, St. Kitts and Nevis was entitled to participate in the flyingfish fishery. If the interest of fishery participation was indeed real, then St. Kitts and Nevis should become more engaged with all aspects of the flyingfish management process, including addressing aspects pertaining to training, and development of an ecosystem approach to fisheries management.

Dr. McConney expressed the need to consider a few methodological refinements with regard to incorporating how people conceptualized terms such as ‘resilience’ differently, and how to include caveats for these different interpretations in the analysis. He also suggested to the incoming CIDA intern to seek out existing indicators in the Marine Protected Areas literature. Dr. Medley stated that pairwise comparisons were also used in ParFish analyses and that he had also experienced issues with respect to assumption bias in interviewers versus interviewees. Professor Seijo suggested that a risk analysis component be considered for the MCA, and provided a reference (Fletcher 2005) in this regard. Ms. Ferrier responded that one of the strengths of the project’s less-structured interview approach was that it was able to clearly highlight the qualitative variability of fisher responses to the same set of concepts. She added that some analysis of the response variability would be included in the final report.

7.2 CLME project

7.2.1 The Caribbean spiny lobster fisheries in Central America, a model for regional research, management, and governance (OSPESCA)

A brief presentation was given by Mr. Perez on OSPESCA’s work with Caribbean spiny lobster fisheries in Central America.

Presentation summary

OSPESCA is an intergovernmental organization that aims to promote a sustainable and coordinated development of fisheries and aquaculture in the context of the Central American integration process drawing up, approving and implementing regional policies, strategies, programs and projects of fisheries and aquaculture. The OSPESCA Members are all Central American countries from Belize to Panamá. In order to ensure the compliance with the agreements, the Regional OSPESCA Unit of Fisheries and Aquaculture was established within the organizational structure, functions and regulations of the SICA General Secretariat, known as the SICA/OSPESCA Unit in San Salvador, El Salvador. This Unit has also a technical support office in Panamá.

Since July 2005 the Policy of Integration of Fisheries and Aquaculture in Central America is in effect for a 10 year period, which is the legal and technical framework governing the work of the Organization. From 2010 all decisions for regional management of fisheries resources and aquaculture are binding. Decisions are made on a participative basis through working groups, national and regional consultative workshops with discussions on the legal and technical basis which eventually brings a proposal that is approved by the OSPESCA Steering Committee, then elevated to the Council of Ministers for final approval and deposited in the SG-SICA, which makes the decision binding.

The complexity and transboundary nature of the spiny lobster species and fisheries have made the Central America Organization of the Fisheries and Aquaculture Sector (OSPESCA for its acronym in Spanish) to develop a model of governance for the management of the fisheries of this species. In 2009 the Council of Ministers of OSPESCA passed the Regulation OSP- 02-09 whereby the management of the fisheries on this species was agreed on by all Central American countries. At present OSPESCA is strengthening the management and application of the OSP-02-09 through the spiny lobster pilot project within the CLME Project.

Plenary discussion

Mr. Gittens enquired whether the Vessel Monitoring System (VMS) policy undertaken by OSPESCA also applied to Associate Member States, such as the DR, and whether each country was individually responsible for their own monitoring of such systems. In response, Mr. Perez noted that at present, Associate States were not part of the VMS system but were expected to be included from 2012. He also confirmed that States were individually responsible for their own vessel information but there was also a central information repository in El Salvador.

Mr. Haughton sought clarification as to which countries were participating in this Caribbean Large Marine Ecosystem (CLME) project. Mr. Perez advised that all Central American countries had been included. However, as the original timeframe for the project had been shortened, the pilot sites had been restricted to Belize, Panama, and Nicaragua/Honduras. Bahamas, Colombia and Jamaica were also considered but would now not likely be included due to the time constraint mentioned above.

7.2.2 The Regional Governance Framework (RGF) Project (UWI)

A summarized update of the RGF was presented by Dr. McConney.

Presentation summary

An overview of the Regional Governance Framework Consultancy for the Caribbean LME Project area was presented. It emphasised the close connection of this consultancy to the case studies for flyingfish and for large pelagics. Scientists were reminded that their work needed to provide outputs that articulated with the governance system in order for their advice to be acted upon. Models were presented that showed how the governance framework may apply to these fisheries. Questions were posed, including: What can help to improve the models or make them clearer for communication? Where and how does the work of this scientific meeting fit into the models? What, if anything, should be done to improve fisheries governance regionally?

No comments or questions were raised.

7.3 JICA Master Plan

This item was included as an information item. Dr. Singh-Renton informed the meeting of the primary purpose of the JICA project in formulating a Master Plan on sustainable use of fisheries resources for coastal community development. She indicated that several key pilot studies were being conducted to help inform development of the Master plan. One pilot study dealt with the improvement of FAD fisheries management, in which statistical monitoring was also being addressed, and another pilot study was facilitating review of the statistical systems. The pilot studies were due to be completed by September, and a dissemination seminar was scheduled for November 2011.

No comments or questions were raised on this item.

7.4 ACP Fish II programme

This item was included as an information item. Dr. Singh-Renton reminded the meeting of the EU-funded ACP Fish I project that was aimed at strengthening fisheries and biodiversity management in ACP countries. The ACP Fish II project was intended to build on the achievements of the earlier ACP Fish I project. ACP Fish II was more global in scope, and had 5 main components, two of which had linkages to scientific meetings activities and concerns. Two proposals had been formulated to address conch assessment and management issues, particularly at the national level. In addition, there was also a proposal to review and improve CRFM’s communication strategy that would involve upgrading of the CRFM website and its tools.

No comments or questions were raised on this item.

7.5 Fish age and growth research (IMA)

This item was included as an information item. Dr. Singh-Renton advised the meeting that the CFF had endorsed the resumption of CRFM support for the age and growth laboratory at IMA, and that a certain amount of funds was approved to be paid to the IMA each year. To facilitate formal implementation of the arrangement, a Letter of Agreement (LOA) had been prepared and had been signed by the CRFM Executive Director on behalf of the CRFM. The LOA was currently with the IMA for review and signature by IMA. In addition, the government of Canada had promised sponsorship for a technical training attachment, but such sponsorship had not yet been formally approved. These delays were creating some frustrations, but the CRFM Secretariat would renew its efforts to finalize the LOA and obtain the attachment.

No comments or questions were raised on this item.

8. Any other business

Mr. Ponteen enquired if copies of the meeting presentations were going to be available and requested the development of a common data sharing policy for the greater community addressing issues of data confidentially and safety.

In response, Dr. Singh-Renton requested to meeting presenters that they submit copies of their presentations to the CRFM for dissemination. She also appealed to meeting participants to provide at least a minimum of information to the CRFM Secretariat for archiving purposes. Mr. Haughton requested that information used in and outputs derived from the meetings always be lodged with the Secretariat as a rule and that countries should apply for an exception to this rule only if needed. He also stated that a data sharing policy had been developed by the scientific meeting some years ago. The CRFM had contracted a consultant to address this issue further and that a regional meeting on this subject was being planned.

In recognition of the difficulty in compiling information from meeting participants after the fact, Mr. Gongora suggested that all relevant documents and information be collected during the meeting and distributed to participants on a CD-Rom. He stated that in order for this to be accomplished, participants would need to submit their presentations ahead of time.

9. Review and adoption of meeting report

The Chair enquired as to the timeline for the submission of the final report. In response, Dr. Singh-Renton proposed that all rapporteurs aim to finalize their report by 1 July 2011. However, if delays were anticipated, Dr. Singh-Renton requested that the rapporteurs advise the Secretariat accordingly. She then informed the meeting that the LPWG rapporteur had already notified her that this Working Group would be unable to submit its final report before the end of July.

It was agreed to adopt the report of the meeting by e-mail.

10. Adjournment

The Chair thanked the CRFM Secretariat staff for all the hard work put into hosting the meeting, and thanked participants for their contributions.

Dr. Singh-Renton, in turn, thanked the Chairperson for her patience, skill and efforts in guiding the meeting through the long and varied agenda and discussions.

The meeting was adjourned on 24th June, 2011, at 6:15pm.

PART II – Appendices

Appendix 1
Meeting Agenda

I. Individual Resource Working Group Sessions: 17 - 23 June 2011

Proposed agenda given in CSM 2011 Document 2(c)

II. Meeting of the DMTWG: 16 & 23 June 2011

Proposed agenda given in CSM 2011 Document 2(d)

III. Formal plenary sessions: 24 June 2011

1. Opening of the meeting.

2. Adoption of meeting agenda and meeting arrangements.

3. Introduction of participants.

4. Presentation of national (country) reports.

5. Reports of the CRFM Fishery Resource Working Groups (listed in alphabetical order):
   - 5.1 Large Pelagic Fish Resource Working Group (LPWG);
   - 5.2 Shrimp and Groundfish Resource Working Group (SGWG);
   - 5.3 Small Coastal Pelagic Fish Resource Working Group (SCPWG).

6. Report of the Second Meeting of the Working Group on Data Methods and Training (DMTWG).

7. Inter-sessional activities:
   - 7.1 CLWG activities;
   - 7.2 RSWG activities;
   - 7.3 CRFM Toolbox and casebook/notebook contributions to CRFM website for 2010-2011;
   - 7.4. Fish age and growth research;
   - 7.5. Activities and progress of the CIDA internship programme hosted by the CRFM.

8. Any other business.

9. Review and adoption of meeting report.

10. Adjournment.

DRAFT ANNOTATED AGENDA – PLENARY MEETING
24 June 2011 (0900 - 1700)

1. Opening of the meeting.
   - *The plenary meeting sessions will be formally opened by a senior official of the government of St. Vincent and the Grenadines during a short ceremony commencing at 0900h on 22 June 2011.*

2. Adoption of meeting agenda and meeting arrangements.
   - *The Chairperson will review the agenda and request that it be adopted by the Meeting. The Chairperson will also confirm general meeting arrangements.*

3. Introduction of participants.
   - *Each participant will be invited to introduce him/herself, and to state his/her interest in the Meeting.*

4. Presentation of national (country) reports.
   - *The Secretariat will be asked to list those national reports that have been submitted for consideration by the 2011 Meeting.*

5. Reports of the CRFM Fishery Resource Working Groups (listed in alphabetical order):
   5.1 Large Pelagic Fish Resource Working Group (LPWG);
   5.2 Shrimp and Groundfish Resource Working Group (SGWG);
   5.3 Small Coastal Pelagic Fish Resource Working Group (SCPWG).
   - *Each Working Group Chairperson will present an overall report of the Working Group's 2011 meeting, including overall findings, recommendations and conclusions.*
   - *Each species rapporteur will also present his/her fishery assessment report for 2011.*
   - *Following each presentation, the Meeting will be invited to review, discuss, and endorse each report's findings and recommendations.*

6. Report of the Second Meeting of the Working Group on Data Methods and Training (DMTWG).
   - *The Chairperson of this Working Group will present the report of this meeting for review and adoption.*

7. Inter-sessional activities:
   7.1 CLWG activities;
   7.2 RSWG activities;
   7.3 CRFM Toolbox and casebook/notebook contributions to CRFM website for 2010-2011.
   7.4. Fish age and growth research;
   7.5. Activities and progress of the CIDA internship programme hosted by the CRFM.
   - *The Meeting will review the progress achieved by inter-sessional activities, and may make recommendations for the way forward, as appropriate.*

8. Any other business
   - *The Chairperson will address any items identified to be addressed under this agenda item.*

9. Review and adoption of meeting report.
   - *The text of the report is reviewed and adopted. If time is limited, the report is to be adopted by email.*

10. Adjournment.

- *The Chairperson will make any necessary closing remarks, and move to adjourn the Meeting.*

Resource Working Group Meeting

Proposed Agenda
17 - 23 June 2011

1. Review of inter-sessional activities, including management developments since last meeting.

2. General review of fisheries trends throughout the region, including recent developments.

3. Review of commitments to the CLME project (LPWG & SCPWG).

4. Review of selected fishery to be assessed - i.e. review available new data and information, including review of national reports, fisheries trends, and management developments.

5. Review of management objectives and possible management strategies – i.e. review of fisheries management plans, stated management objectives and agreed, practical management strategies in order to agree on the approaches to data analyses and assessments for the present meeting.

6. Fishery data preparation, analysis and assessment planning and implementation, and report preparation.

7. Review and adoption of working group report, including species/ fisheries reports for 2011.

8. Inter-sessional workplan.

9. Any other business

10. Adjournment.

Working Group on
Data, Methods and Training (DMTWG)

Draft Meeting Agenda
16 & 23 June 2011

1. Opening of meeting.

2. Adoption of agenda and meeting arrangements.

3. Training sessions.

4. 2010 - 2011 inter-sessional activities.

5. Issues and recommendations pertaining to:
   5.1 Data;
   5.2 Methods;
   5.3 Training.

6. 2011-2012 inter-sessional activities.

7. Any other business.

8. Adjournment.

Appendix 2
List of Participants

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Appendix 3: Report of the Conch and Lobster Resources Working Group (CLWG)

Chairman: Lester Gittens
Consultant: Dr. Paul Medley

A. Introduction

The Conch and Lobster Working Group meeting was attended by representatives of Anguilla, The Bahamas, Belize, Jamaica, Montserrat, St Kitts, St Vincent and the Grenadines, OSPESCA, as well as Dr Paul Medley (Consultant).

This year's meeting was specially convened to facilitate the peer review of a Caribbean spiny lobster stock assessment that was conducted inter-sessionally in The Bahamas during 2010 (see Annex 1). The assessment was conducted as part of a lobster fishery improvement project aimed at bringing the fishery up to Marine Stewardship Council (MSC) certification standards.

Time was also allotted to discussing lobster and conch related issues that other countries wished to raise. Issues that were raised included:-

1. A CLWG meeting should be convened at the next Scientific Meeting so that countries can discuss progress made and further strategize as a region.
2. It was also felt that a wider regional meeting possibly involving the WECAFC is overdue.
3. Nicaragua has implemented a quota system that may be of interest to other countries. A presentation of how Nicaragua's system works should be considered for the next meeting.
4. The regional review of the lobster fishery conducted by the CRFM should be presented at next year's meeting.

1.0 The spiny lobster (*Panulirus argus*) fishery of the Bahamas.

1.1 Management Objectives

The management objective for the spiny lobster fishery is to ensure that spiny lobsters are harvested for maximum economic benefit and in a sustainable manner. This is unofficial as a fishery management plan is still being developed.

1.2 Status of Stocks

Based on the inter-sessional stock assessment, the lobster fishery is believed to be in a good state. The stock assessment is believed to be the best to date and is based on exhaustive analysis of the best data available.

1.3 Management Advice

Given the great economic importance of the lobster fishery and the role it plays in recruitment in the region, every effort should be made to further improve the assessment.

1.4 Statistics and Research Recommendations

1.4.1. Data Quality

The data analyzed was not ideal hence the longtime difficulty of assessing the fishery. Although this is the best assessment to date, it is still recognized that there is a less than ideal amount of uncertainty. This cannot be changed for the historic data but new data collection efforts can address this. An improvement in data quality is fully expected and it is expected that the implementation of a Catch Certificate programme will facilitate this. This program was initiated at the beginning of the 2010 - 2011 season in an effort to comply with European Union demands.

1.4.2. Research Needs

It is recommended that research be conducted on the impact of casitas on the lobster fishery. It is unknown whether casitas enhance the fishery by increasing total production, whether their aggregating effects simply hasten overfishing or whether each circumstance prevails in certain situations. Research in this area is expected to begin during mid 2012.
Fishery independent data is also needed to enhance the stock assessment.

1.5 Stock Assessment Summary

Stock assessment results indicate that the biomass of spawning lobsters is well above levels of concern. Figure 1 shows the estimates relative to internationally recognized reference points. The suggested target reference point was 40% spawning stock biomass (SSB), 30% SSB as a trigger for management intervention and 20% SSB as the point at which all fishing should cease.

Diver catch per unit effort was used as a proxy for SSB and was suggested as for use in a harvest control rule. It is suggested that management intervention should take place when catch per unit effort goes below 30lbs (13.61 kg) per man/day for divers or if 7 million lbs (3.18 million kg) of tails is exported. The suggested management action would involve limiting exports as this is the main driving force behind the fishery.

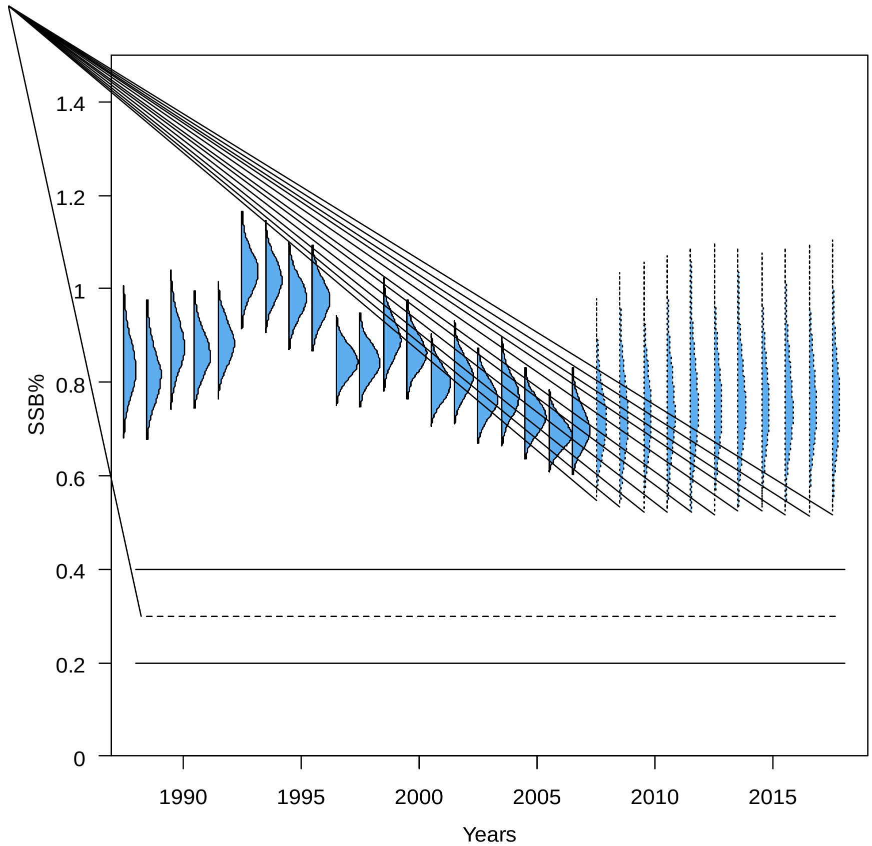

Figure 1: Spawning Stock Biomass Per Year

1.6 Special Comments

A number of suggestions were received that would either improve the accuracy of the stock assessment or enhance management of the fishery in other ways. These include:-

1. Make efforts to estimate local consumption as this fluctuates and can be significant if other countries are used as an example.
2. Explore directly limiting effort to control the fishery should intervention be needed. Belize has implemented such a system which can be sued as an example.
3. When local consumption is further investigated, it is suggested that at 5% and below the local consumption would be insignificant.
4. The views of fishers should be incorporated into assessment efforts if they can be sufficiently quantified.
5. Attempt to look at recruitment trends in Cuba and Florida to further estimate recruitment in The Bahamas.
6. Conduct simulations of what the status of the stocks would be if the assessment was done on bank by bank basis.
7. Obtain better data going forward. This includes fishery dependent and fishery independent data.

Annex 1: 2010 Bahamas Spiny Lobster Stock Assessment

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1. Preparation of this Document

This document has been prepared for the Bahamas Fisheries Improvement Plan. It documents work done and results particularly addressing Principle 1 under the Marine Stewardship Council Principles and Criteria (MSC P&C).

The assessment and advice presented here has not yet undergone peer review. Various outputs from the assessment, including management advice should be reviewed and changed as considered appropriate by an independent scientific working group. As such, this report's conclusions (Sections 3 - 11) will be subject to evaluation and change before gaining any official status in the harvest strategy.

2. Recommendations for the Fisheries Improvement Plan

The main objective of this study was to support the Fisheries Improvement Plan (primarily task 4.3), which aims to help the fishery meet the MSC standard. On completion of the work, the tasks identified in the plan relevant to Principle 1 were reviewed and remaining tasks identified which need to be completed (Table 1).

Two major gaps have been identified which need to be addressed:

1. It is recommended that a Bahamas Spiny Lobster Working Group is established which consists of representatives of all major stakeholders (i.e. relevant Government staff, processors, fishers, scientists) who will advise government of actions which need to be taken to implement and be consistent with agreed policy. Such a working group could form the focus for many of the requirements under the MSC standard, including all performance indicators under MSC P&C 1.2 and 3.2, as well as addressing 3.1.2, and all management strategies under Principle 2. Bearing in mind that managing fisheries is an on-going process, the Working Group would exist to address any issues in future as they arise. The first objective of the Working Group would be to take the fishery forward as quickly as possible to certification.
2. The main remaining hurdle for meeting MSC P&C for Principle 1 is the data collection system (FIP tasks 1.1 – 1.3). A minimum requirement will be reliable data collection and management reporting information rapidly and accurately enough that the harvest control rule can be applied, as well as providing the longer term needs of an improved stock assessment. It is not clear that the DMR or the processors can do this without technical support. It is important to note that the primary data collection would be implemented with the processors, not the DMR, although the DMR would need to verify and manage their part of the system.

Table 1: Evaluation of tasks relevant to the FIP and MSC certification

No.	Task	Comments
1.1	Development of revised data collection form	The current fisheries information system is not good enough to support the harvest strategy. Even where data are now being collected in a more rigorous fashion, they need to be made available through an information system. This will be critical for all four Principle 1 management performance indicators (P1.2.1 -
1.2	Initiate data collection at processors	
1.3	Update and maintenance of	

	Fisheries Information System	4). Currently, the processors and DMR do not have the capacity to carry out these tasks.
2.	Education and Outreach (all tasks)	The proposed Bahamas Spiny Lobster Working Group should have a role in carrying out all tasks under these headings.
3.	Enforcement (all tasks)	
4.1	Demonstrate effectiveness of MPAs	This has been marked as high priority for the stock status determination and assessment, but this information is not necessary for either. It is difficult to see what can be done to address this in the short term, and it should not be necessary to address before the full MSC assessment. The current role of MPAs in the harvest strategy is to reduce general risk factors for the fishery only, and this can be argued effectively without the completion research.
4.2	Develop in-house capacity to conduct stock assessments	This is an on-going requirement and need not be completed before full MSC assessment.
4.3	Develop stock assessment, harvest control rules and reference points	This report addresses these issues. A stock status determination has been made; reference points and harvest control rule have been proposed. The next stage of the process will be to carry out the scientific and management review. It is planned to have the CRFM Conch and Lobster Working Group conduct the scientific review of the stock assessment, HCR and management advice. The management review should be undertaken by the Bahamas Spiny Lobster Working Group (see above).
4.4	Growth, minimum size at capture and maturity	There is information in the scientific literature to support the minimum size. In addition, a maturity study can be conducted rapidly to provide an estimate of the onset of maturity between November 2010 and April 2011. This is likely to support the current minimum size. Growth estimates would be valuable, but are unlikely to be conducted before full assessment, unless full assessment was significantly delayed. Even without new data, an argument can be constructed to support the current minimum size.
4.12	Develop a research plan to investigate the prevalence of lobster virus PaV1	This task has been identified incorrectly as a high priority for determining the status of the stock. It is not necessary for determining stock status, but it is a long term task providing useful information for the harvest strategy and possibly stock assessment modeling, as well as market quality of the product.

3. State of Stock

The latest stock assessment using all the available catch and effort data indicates that overall the Bahamas spiny lobster stock are not overfished and overfishing is not occurring. This can be interpreted as there being no evidence in these data of overfishing. However, precise determination of stock status is not possible due to limited relevant information in the available data.

Previous stock assessments based on other data have indicated very high exploitation rates. These over-estimates of the exploitation rates were thought to be due, at least in part, to limitations on models and data in capturing the main characteristics of the population dynamics and the fishery. This limitation is also thought to apply to the latest assessment, although the problem is less severe.

4. Management Advice

Although the assessment indicates the Bahamas stocks are in a good state, the uncertainties associated with this assessment, and an inability at this stage to provide advice for specific populations within the Bahamas archipelago, suggest that the stocks should be treated as fully exploited until more and better information becomes available. Therefore, management controls should be applied which will directly limit exploitation to the current level and prevent any further expansion. Central to this advice is to establish a harvest control rule.

5. Reference Points

Internationally recognized precautionary reference points should be adopted to protect the stock. It is not possible to reliably estimate reference points based on maximum sustainable yield, so generic points appropriate for the stock should be used. The biomass relative to the unexploited biomass can be estimated and therefore this should be used as the basis for reference points.

A limit reference point is proposed which is set at 20% of the unexploited spawning stock biomass (SSB). If the SSB falls below this point the stock should be considered severely overfished and catches should be minimized, which could include a ban on exports.

A target reference point is proposed which is set at 40% of the unexploited spawning stock biomass. An important objective of the harvest strategy should be to maintain the stock so that it fluctuates around the target or remains above it.

6. Harvest Strategy

The harvest strategy currently has two main components:

1. To ensure that the optimum size composition is maintained in the catches; and the selectivity pattern provides as much protection to spawners as possible. This is currently being achieved through a minimum size and closed season.
2. To ensure the exploitation rate is maintained at a level commensurate with the productivity of the stock and appropriate action is taken to reduce exploitation when the risk to the spawning stock has increased to an unacceptable level. It is planned to achieve this through the implementation of the harvest control rule.

However, the current harvest strategy is not fully developed, but requires a well defined process implementing a feedback-control system. A system which evaluates its own performance is the only way to ensure sustainability.

It is recommended that a Bahamas Spiny Lobster Working Group be established to evaluate and advise on the management of the Bahamas lobster fisheries. Terms of reference for this working group are being distributed for consultation. Establishing such a group would meet a number of requirements for MSC certification under all three Principles. One of the important tasks of the group would be to implement and evaluate the harvest strategy, and in particular be responsible for timely and accurate application of the harvest control rule.

7. Harvest Control Rule

A harvest control rule (HCR) has been proposed which will contribute to the harvest strategy by ensuring the exploitation rate is reduced when the apparent stock size falls below the trigger point (Box 1). The decisions that result from the HCR are taken based on an index which is calculated from data collected at the beginning of the lobster season. There are a number of indices which could be calculated, and it is recommended that at least two are estimated each year to help with the evaluation and auditing of the rule. Indices include:

- The index which is currently suggested for the HCR is the average catch (tail weight) per man day taken by divers during August. Historical information already exists to propose appropriate reference points for this index, although the true behaviour of this index might only become apparent under the new data collection system which has only recently been implemented.
- An index obtained from fishers who are preparing for the season in July. Fishers would collect standardized information on abundance from condominiums and diving activity which could be sent into the Department of Marine Resources and combined into an abundance index. While this has the advantage of involving the fishing community in implementing the rule, there is no current information that might be used to evaluate this approach and the data may be difficult to validate.
- A fishery independent index obtained by DMR staff and others during the closed season by inspecting condominiums and traps. There is no current information that might be used to evaluate this approach and obtaining a valid sample representing the large fishery area involved may be difficult and expensive to achieve.
- Mean size as calculated from the commercial size composition reported as part of the export procedure. The mean size would cover the whole year and is not suitable for the harvest control rule, but provides a useful comparison for other indices.

The details of the data collection system for the index and the necessary auditing that will be required to ensure it is correct have not yet been developed.

Box 1. Proposed Harvest Control Rule for Bahamas Spiny Lobster. The terms in bold-italics need to be reviewed by a scientific working group to test whether they are consistent with each other and precautionary and based on the best scientific advice currently available. Note that a valid sample for calculating the index has yet to be determined and the maximum export of 7 million pounds needs to be verified.
The Total Allowable Export shall be set at:

- ***7 million pounds*** lobster tails when the index catch rate is at or above the trigger index.

- a linearly declining value when the current index is below the trigger index according to the calculation:
  - TAE = (Current Index – Limit Index) * ***700000*** lbs tails
  - ***zero (the fishery is closed)*** if the current index is at or below the limit index.
  - The trigger index shall be set at ***30*** lbs per man day.
  - The current index for each year shall be calculated as the average between the previous year's index and index of the current year. The index is calculated from the catch divided by the number of man days required to obtain that catch for a valid sample taken from the August diving activity.
  - The target index shall be set at ***40*** lbs per man day and the limit index shall be set at ***20*** lbs per man day.

- The year to year change in the TAE shall not vary by no more than ***15%***.

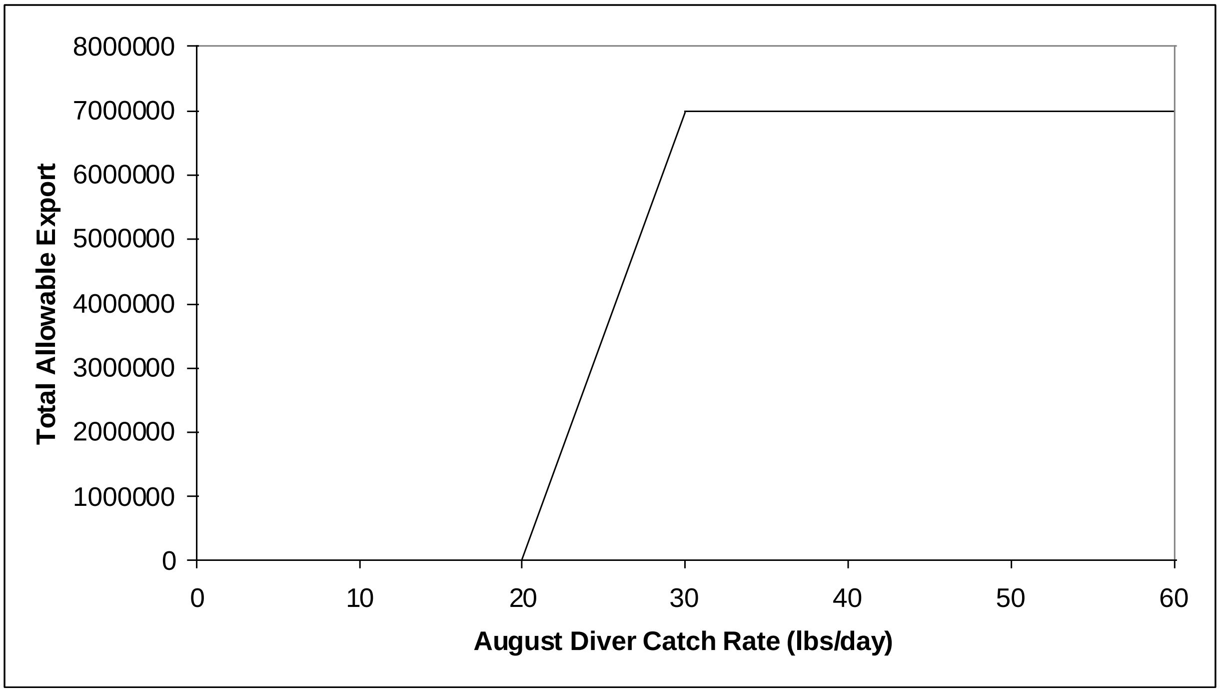

Figure 1 The proposed harvest control rule linking the index observation to the maximum allowed export in each year. This is the graphical representation of the rule in Box 1.

The maximum level of catch currently proposed will not reduce the size of the fishery, but will prevent further expansion. If recruitment continues to decline it will decrease the landings and protect the fishery. However, it still needs to be demonstrated that under this rule catches can be reduced fast enough to protect the stock.

8. Stock Assessment

A simple model was used building on previous developments of data and models for the Bahamas (see CRFM 2006, 2007a, 2008, 2009). A technical description of the stock assessment is given in Section 9. The assessment used all available data (catch and fishing effort time series and total exports), with the exception of the size composition data which is based on commercial size categories. This stock assessment represents the best assessment to date (Table 2).

The time series of size composition data was reserved to test results from the main assessment. These data have been used previously to conduct an alternative independent assessment based on size alone. In future and if possible, these sources should be combined into a single assessment model.

A Bayesian statistical method is used to fit the model of the stock dynamics to the available data. This method explicitly models uncertainty, which is therefore well accounted for and can be included in the scientific advice. The Bayesian framework allows additional information on life history to be used which otherwise would have to be excluded.

Table 2: Summary of stock assessment results. Adult biomass is treated as spawning stock biomass, as the model does not attempt to estimate spawners directly (See Section 9). The remaining values are indicators of interest. Although the model was fitted to data up to and including 2007, the catches in months January – March 2008 appeared incomplete and therefore 2006 is reported as more reliable. The 90% confidence interval for B/B_{MSY} and F/F_{MSY} exclude 1.0, indicating that there is only a very small chance that the stock was being overexploited in 2006. Note, however, that these confidence intervals do not take account of the structural errors in the assessment, which are the largest source of uncertainty. These have been addressed by a number of sensitivity analyses.

	0.05	Median	0.95
Adult Biomass 2006 (SSB_{2006}, '000 lb)	37762	44638	51595
Unexploited Adult Biomass (SSB_0, '000 lb)	57447	64684	71321
Adult Biomass at MSY (SSB_{MSY}, '000 lb)	12241	13871	15339
Yield 2006 ('000 lb)		5480	
MSY ('000 lb)	15369	17137	18843
F_{2006} (year^{-1})	0.120	0.138	0.161
F_{MSY} (year^{-1})	1.191	1.311	1.398
SSB / SSB_0	0.639	0.689	0.745
SSB / SSB_{MSY}	2.982	3.217	3.476
F / FMSY	0.090	0.106	0.127

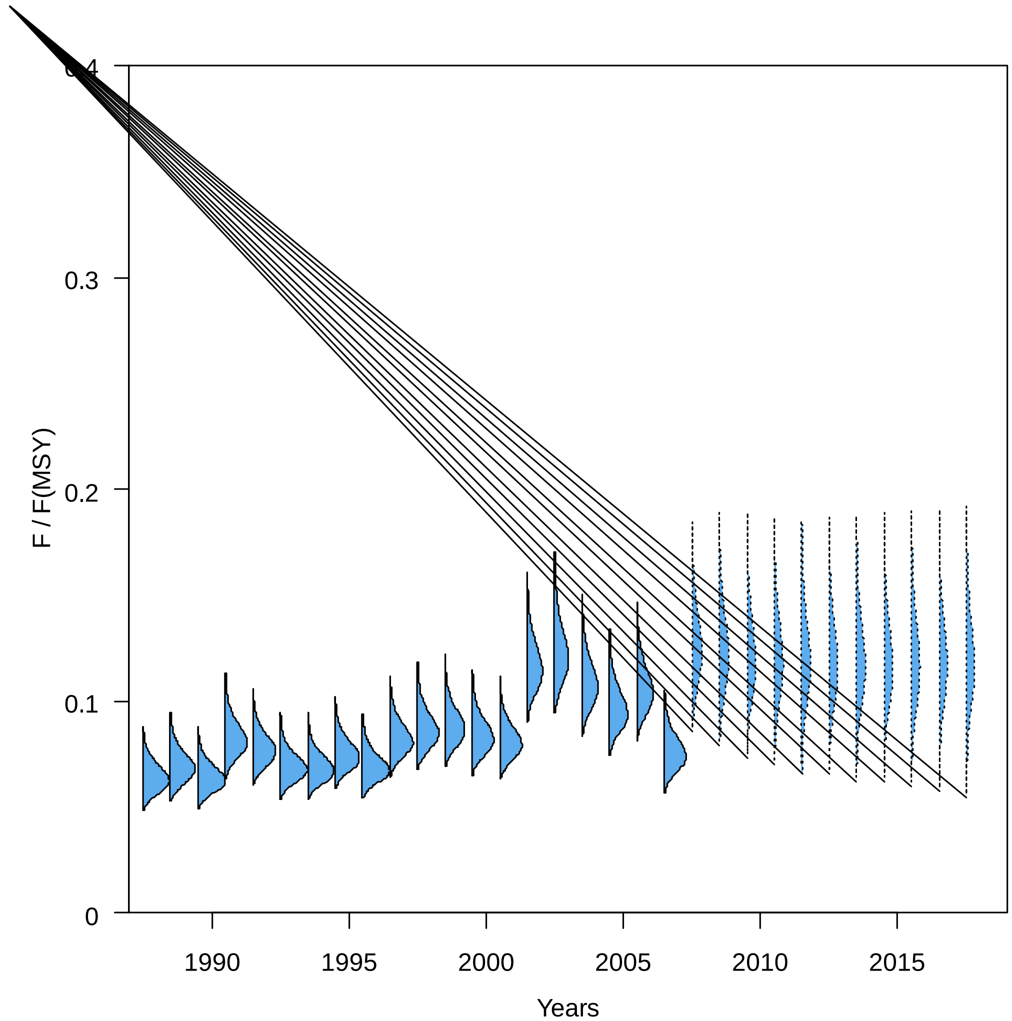

Figure 2: The F / FMSY statistic indicates whether overfishing is occurring. The curves represent estimated (solid) and projected (dotted) probability density functions estimated from the model and data. As almost all the probability mass (represented by the Monte Carlo Frequency) is well below 1.0, this indicates that the exploitation rate is below that required to obtain the maximum sustainable yield and therefore appears safe. There is no evidence from the catch and effort data of overfishing on this stock.

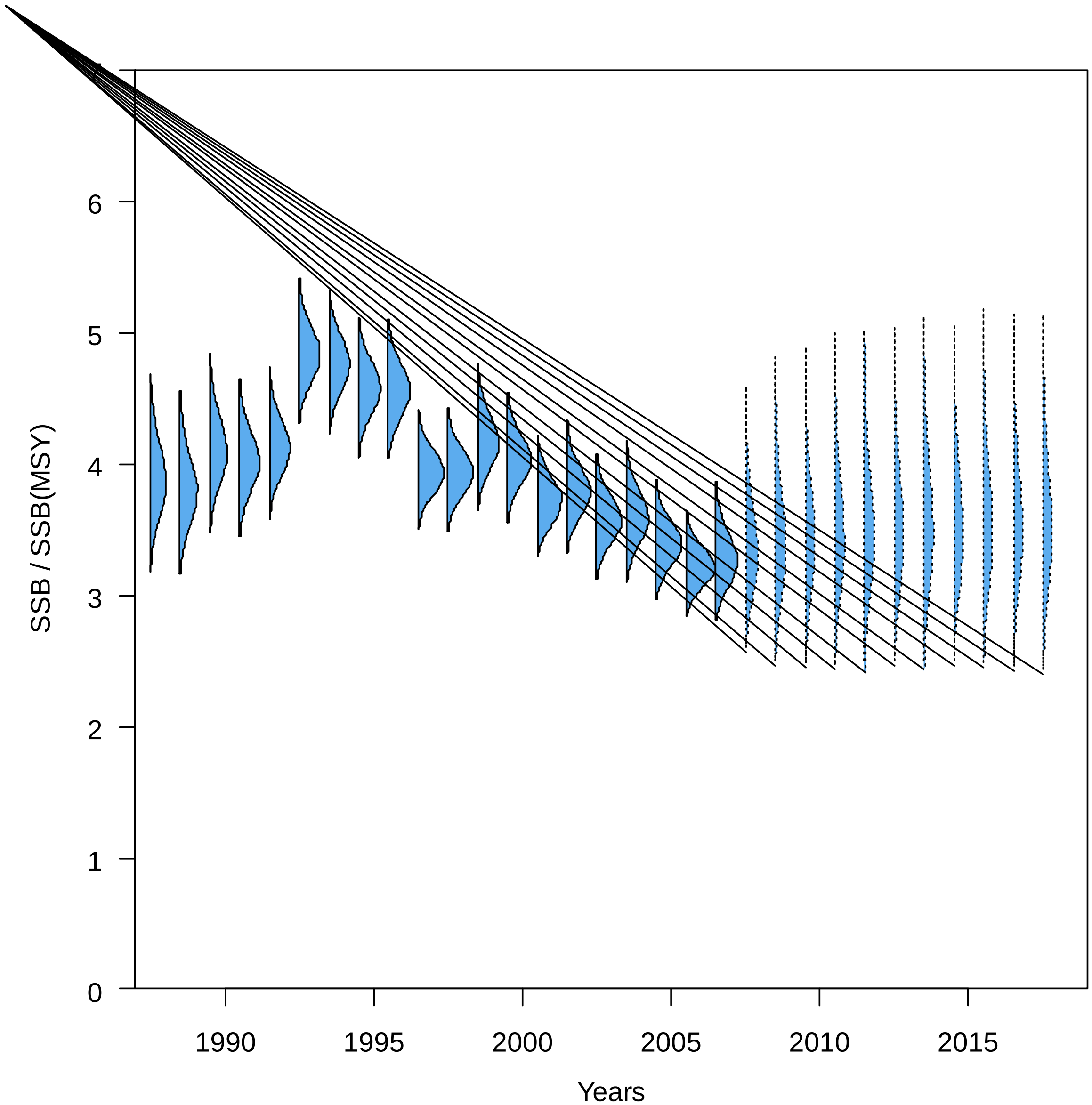

Figure 3 SSB / SSBMSY is used to indicate the state of the stock. The fact that almost all the probability mass is above 1.0 shows that the biomass is well above that which would maximize the yield. There is no evidence from the catch and effort data that the stock is overfished.

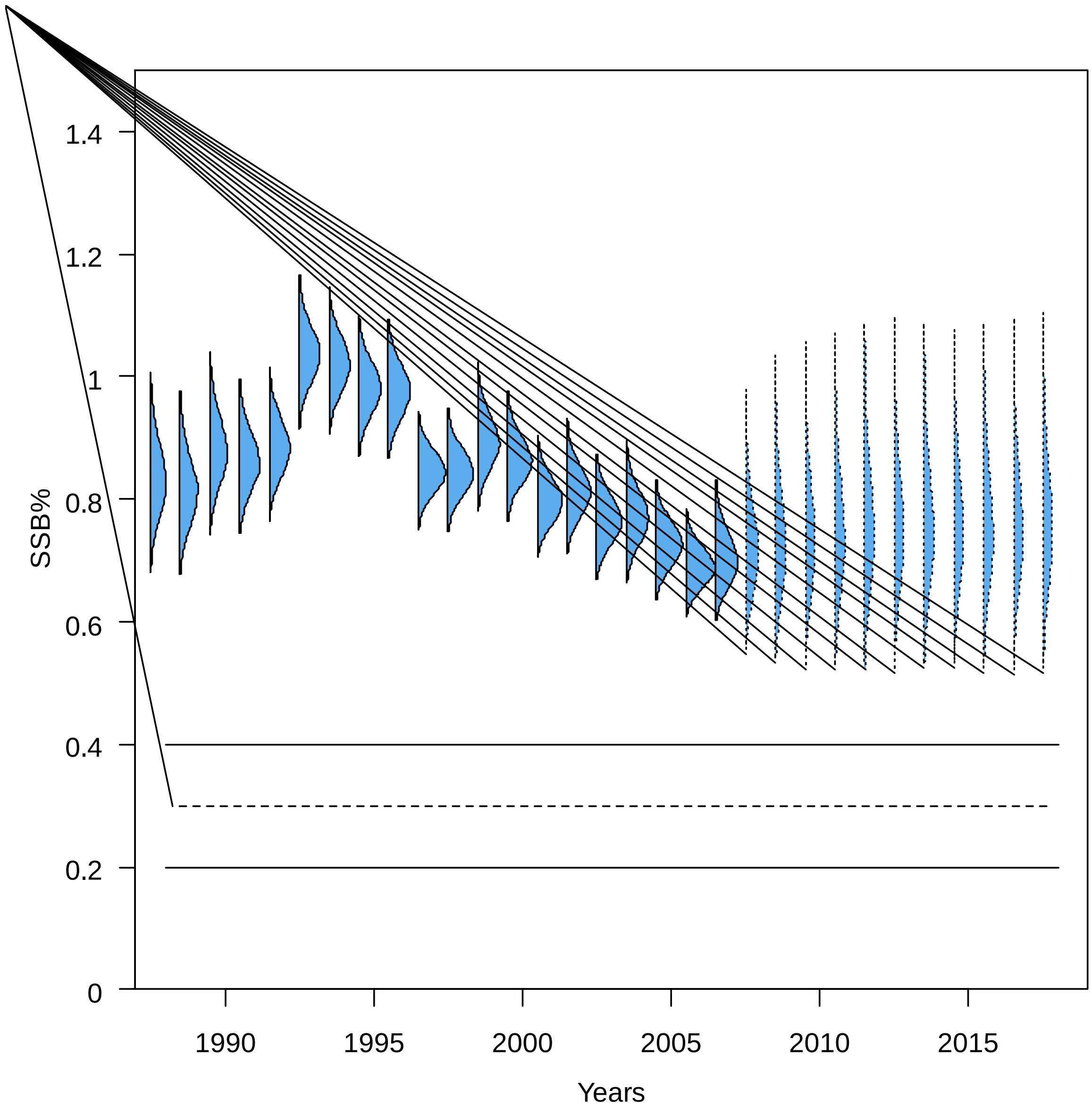

Figure 4 Adult biomass development from the start of the available data time series (1988) relative to the reference points. The dotted lines show the projection of the biomass when the default harvest control rule is applied. In all years, the stock is well above the target level (0.4), and therefore the stock appears safe.

Sensitivity analyses were conducted but were not exhaustive. Defining and conducting sensitivity analyses should be the responsibility of the scientific working group which will review the stock assessment.

The sensitivity analyses conducted altered the prior probabilities used in the fitted model. The prior PDFs used in the Bayesian fitting method are informative and influence the results. These priors are generated from information outside the data available from the Bahamas, and they require additional assumptions.

Table 3 Sensitivity analyses and general conclusions drawn from their results. A full set of sensitivities will be conducted as part of the scientific review process. The most important task would be to identify scenarios covering all likely "states of nature" so that the harvest control rule can be rigorously tested and parameterized so that it is precautionary.

Name	Description	General Result
M = 0.2	Natural mortality was effectively lowered from 0.36 to 0.2 year^{-1}. A lower natural mortality than expected might be explained by the widespread availability of condominiums, for example.	There was very little change to the general result of the assessment, and the status of the stock was unchanged.
M = 0.5	Natural mortality was effectively increased from 0.36 to 0.5 year^{-1}. A higher natural mortality than expected might be explained by the increased incidence of disease, for example.	There was very little change to the general result of the assessment, and the status of the stock was unchanged. The level of uncertainty increased somewhat as the stock size became more dependent on recruitment.
70% Recruitment	The base case assessment assumes equivalence in productivity per unit area between the Caicos Bank and the Bahamian banks in this assessment. An alternative is that the Bahamian banks are less productive due to, for example, proportionally less good quality lobster habitat. An arbitrary reduction of 30% was tested.	The state of the stock decreased, although at this level of expected productivity still remained well above the target reference point. However, there is a clear dependence of the assumed recruitment level and therefore a strong influence of the Caicos bank stock assessment.
Alternative Recruitment Model	An alternative model might be that there is proportionality between the bank perimeters or lengths rather than area. For example, the profile banks present to oceanic currents might contribute to larval settlement. Therefore, the level of recruitment between the Caicos and Bahamian banks was set based on the square root of the area ratios.	The net result was a much more severe reduction in productivity than 30% in the previous sensitivity analyses, and therefore a more severe reduction in stock status. In this scenario, the stock was relatively depleted, and the harvest control rule was unable to guarantee a sustainable harvest. This might suggest that a 15% constraint on the year-to-year change in TAE is too small.

9. Data Used

Exports of spiny lobster provided accurate estimates of the total catch. The date of export rather than of capture was available, so some adjustment was made to the model to allow for this.

The abundance of the stock was estimated based on catch and effort data. Catch and effort was recorded at landing through interviews with the vessel captain. The date, gear and measures of the trip catch and effort are recorded from each interview. These allowed separate treatment of the main gear types as abundance indices, and separation of the population into juvenile and adult components.

10. Technical Report

10.1 Available Data

Total exports of spiny lobster tails by commercial size grade are reported to the Department of Marine Resources (DMR) by the processors. The date of catch is not known from these data.

The date of catch was estimated from the processing and export delay (CRFM 2009). This suggested at the very least a two week delay between landing and export. Further delays might be attributed to trip length and shipment delays. However, it was decided that half of all exports in any month would be allocated to the previous month as they were likely caught in the previous month, with exceptions of August (none reallocated) and April (all reallocated). This should be re-evaluated when the better data currently being collected becomes available.

Catch and effort were available by trip for a sample of trips. The total number of trips is unknown. Trips are not sampled randomly, although the trip interviews are thought to be representative. The gear types can be split into four main types: diving with spears, diving with hooks (use condominiums), lobster traps and fish traps. Catch and effort data has not been considered reliable in previous assessments and considerable work has been devoted recently to cleaning the data (CRFM 2009). While the resulting catch and effort data still has significant variance as an abundance indicator, it shows patterns consistent with the population dynamics of Caribbean spiny lobster, and is now considered adequate to apply basic stock assessment methods.

10.2 Stock Assessment Model and Likelihood

Seasonal recruitment provides contrast to fit the population model. Recruitment is thought to occur in the May-July during the closed season. After the season has opened on 1st August, the population is exploited and declines. This depletion can be monitored using an abundance index and the total catch. This method was used to assess the Turks and Caicos Islands fishery (Medley and Ninnes 1997), which is very similar. The Turks and Caicos Islands are at the southern end of the Bahamas chain and have the same physical geography as the other parts of the Bahamian archipelago.

The population model splits recruits and juveniles from the adults, which form the spawning stock. This was required in this model because the different fishing gears take different components of the population. Diving targets new recruits particularly, whereas trap gears are able to exploit the deeper water where mature adults tend to be found. The recruited population is modeled as:

$$R_{t+1} = R_Y + R_t\, e^{-(M+G)} - C_{Rt} e^{-0.5M}$$

Where R_t = population size in month t, M = natural mortality and G = transfer rate to the adult population, C_{Rt} = catch of recruits and R_Y = new recruits. $R_Y = 0$ in all months apart from August, the beginning of the fishing season, when it is estimated. The adult population model is:

$$S_{t+1} = S_t e^{-M} - C_{St} e^{-0.5M} + R_t \frac{G}{M+G}\left(1 - e^{-(M+G)}\right)$$

Where S_t = population size in month t.

The population models do not account for growth directly, and are limited to the same units used in the catch and effort data. Essentially, the additional approximation is the average size in the recruit and adult populations is constant. Some correction may be possible by converting catch weight to numbers using the export size composition in future assessments. However, this is not straightforward and some size composition data from the different gear types may be necessary.

While not part of the fitted model, a Beverton and Holt stock-recruitment model is used for the projections and to estimate the MSY reference points:

$$R_Y = \frac{4hR_0 S}{R_0\ S_{PR}\ (1-h) + S_Y(5h-1)}$$

This model relates R_Y, the expected recruitment in year Y, to S_Y, the adult stock size 3 years previously. This three year delay is consistent with the size at recruitment. While the unexploited recruitment parameter (R_0) can be estimated from the data, steepness (h) cannot and a range of fixed values from 0.75 (very precautionary) to 0.9 (least precautionary) were considered. A default and reasonably precautionary value of 0.8 was chosen for the purposes of this assessment. The spawning biomass per recruit (S_{PR}) for the unexploited stock was estimated using published growth, length-weight and natural mortality estimates for stocks around the region.

The data available to fit the model was the total catch provided from processor exports, and catch and effort data based on trip interviews. Each trip recorded the gear used, lobster catch weight, number of fishers and number of fishing days, among other things. Four gears were recognized. Previously spears dominated as the main diving gear, but with the wider use of condos (a.k.a. casitas), hooks have become more common. Since hooks with condos are generally more efficient, these gears were separated. As well as traps targeting lobster, fish traps also reported catches. However, fish trap catches, not surprising, were much lower. This gear was clearly not as efficient and catches taken by fish traps appear rare and very inconsistent. Therefore, this gear was not used in the assessment, so there were only 3 gear types recognized.

The expected catch taken on a particular trip was estimated from the population models as:

$$\hat{C}_{ij} = (q_{iR}\, R_t - q_{iS} S_t) f_j$$

Where q_{iR}, q_{iS} = catchability of gear i on the recruit population and adult population respectively, and f_j = fishing man days used by the trip. All 6 catchability parameters were estimated as part of the model based only on the catch weight and effort data. No size data were available to use as part of this model. Alternative effort measures were considered, but were found to be generally poorer. The fishing man days showed the highest linear correlation with catch as might be expected for a good effort measure.

Exploration of the relationship between catch and effort within each month suggested that the catches were over dispersed compared to the normal probability density function (PDF), but relatively under-dispersed compared to the log-normal. A square-root transform appeared to stabilize the variance, suggesting an underlying Poisson PDF. The compromise was to use the transformed variable in the likelihood, such that log-likelihood was calculated as:

$$L = -\sum_{j=1}^{n} \frac{1}{2} \left(\frac{\sqrt{C_{ij}} - \sqrt{\hat{C}_{ij}}}{\sigma} \right)^2 - n\,\mathrm{Ln}\left(\sqrt{2\pi}\sigma\right)$$

Where n = number of data records available, and the single error parameter (σ) was estimated for all gears. The likelihood was used in the Bayesian fitting procedure.

10.3 Probability Priors for Stock Assessment Parameters

10.3.1 Summary

The priors used in the assessment bring important information from outside the Bahamas to help inform the stock assessment. The Bahamas data alone is not adequate to estimate the state of the stock and reference points. The priors used are informative and influential and require their own assumptions which need to be considered as part of the model. These assumptions should be tested through sensitivity analyses.

Table 4 Summary of informative priors used for the different parameters in the model. In all cases, a normal PDF was used with Mu (mean) and Sigma (standard deviation) parameters.

Parameter	PDF	Mu Caicos	Mu Bahamas	Sigma	Source / Notes
Transfer Rate (G)	Log-Normal		-1.99	0.6948	Simulation based on maturity and growth
Natural Mortality (M)	Normal		0.36	0.0077	Medley and Ninnes (1997). Sigma scaled down from 0.077
Initial Adult (A)	Log-Normal	14.2556	17.5840	0.1742	Medley and Ninnes (1997) and CRFM (2007b) Mu parameter was scaled up based on the ratio of bank areas between the Caicos and Bahamian Banks
Recruitment (R)	Log-Normal	14.0963	17.4247	0.2749	
Bank Area (Sq km)		6500	134447		Sealey et al. (2002) Used to scale Mu parameters for Initial Adult and Recruitment above.

10.3.2 Transfer Rate

The transfer rate (G) between juvenile and adult populations can be approximated using life history information. The transfer rate was primarily driven by growth and the maturity ogive and controlled the rate at which the adult mature stock was replenished by the recruits. The parameter was estimated using a simple simulation based on randomly drawn parameters for growth and maturity.

Because the aim is to generate a prior for the transfer rate, parameters were drawn at random from probability density functions (PDF) representing the regional variation and uncertainty. The Monte Carlo approach allows the hyper-parameters of the mean and variance to be estimated for the transfer rate PDF. All information used to define parameters was taken from information in Chapter 3 of the previous FAO Spiny Lobster Meeting in Merida (FAO, 1998) and M.E. de Leon (personal communication). The parameters are drawn from parametric probability distributions, with the exception of the growth parameters and logistic maturity model. 1000 simulations were completed.

The transfer rate estimate was based on a standard spawners-per-recruit calculation using a Thompson and Bell (1934) approach. However, in this case, mortality and weight is not modeled, since the rate of transfer from recruits to mature adults is conditional on the animal being alive. Each simulation estimated a single transfer rate parameter and was based on a single random draw of the growth and maturity parameters.

The calculations were done over small time steps (0.05 years), where parameters are fixed within the time step. Length was calculated as the von Bertalanffy growth equation:

$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right)$$

where L_t = carapace length at age t, L_∞ = asymptotic length, K = instantaneous growth rate, t_0= effective age at settlement when t = 0. Because t_0 had not been estimated in a number of growth models in the region, the carapace length of the puerulus at settlement (L_0), which was thought to vary little (Table 5), was used instead, so t_0 can be calculated as:

$$t_0 = -Ln\left(1 - \frac{L_0}{L_\infty}\right)\Big/K$$

There were 52 sets of growth model parameters estimated for *Panulirus argus* using a variety of estimation methods. These cover a wide range of parameter values with more estimates close to what are thought to be the most likely true values. The variation not only represents model fitting error, but also possible changes in growth across the region and correlation between the growth rate (K) and asymptotic size (L_∞). To reflect this structure and variation, a non-parametric method was used to construct a density over this frequency using kernel smoothing (Silverman 1986). A normal kernel smoothing parameter was fitted to the standardized principle component scores of the Ln (K) and L_∞ values. This preserves the linear correlation structure among parameter values, but allows fitting one-dimensional smoothing parameter to the two uncorrelated directions to create a multivariate smoothing covariance matrix. The fit was based on a score function which minimizes the mean squared error between the estimated and true density (see Silverman 1986 for details).

Drawing random values from the non-parametric probability is straightforward. A random growth model is chosen which provides the K and L_∞. Multivariate normal random values are generated and scaled using the smoothing matrix, then added to the selected K and L_∞. The transforms (logarithm and standardization) and reverse transforms need to be applied to avoid numerical precision errors. The resulting parameter draw should reflect the actual growth model parameters reported and is similar to choosing random paired parameters from the growth models without the smoothing procedure.

The maturity model uses the logistic curve representing frequency of tar-spotting (Medley and Ninnes 1997). This, in essence, represents the judgment of male lobsters as to the chance of successful reproduction. While it does not necessarily ensure correct state of maturity for individual animals, it almost certainly provides a good population level index.

$$T_t = \frac{T_{max}}{1 + e^{-r(L_t - T_{50\%})}} \qquad 1)$$

where T_{max} = maximum proportion of tar spotted females in the population, $T_{50\%}$ = the length when the proportion of tar spotted females is 50% of the maximum and r = steepness of the logistic curve. This, with the growth curve, allows the proportion mature at each age to be calculated. The logit parameters have standard errors available from the original fit (Medley and Ninnes 1997). These standard errors were used to generate random logit parameter values to which a logistic model was fitted using least-squares. This was done for each simulation.

The mature proportion at each age was then approximated from the age at recruitment (t_R) and a transfer rate parameter.

$$\begin{array}{ll} 1 & t \le t_R \\ T_t = T_{max} e^{-G(t-t_R)} & t > t_R \end{array} \qquad 2)$$

The transfer rate (G) was then estimated in each simulation so as to minimize the squared difference between the estimates from equations 1) and 2). Clearly, this model could not be an accurate representation of the change in maturity, but a direct use of equation 1) in the stock assessment population model was too complex. The resulting simulated frequency resembled a log-normal (Figure 5) with mean -1.99 and standard deviation 0.695.

Table 5 Parameters and how they are simulated from a probability density function.

Parameters	**Probability Density Function**
L_∞, K	Estimated PDF for all available growth in the region using kernel smoothing.
L_0	~ N(5.7, 0.5)
t_R	~ N(80, 6.47)
T_{max}, $T_{50\%}$, r	Estimated on each simulation by a least-squares fit to random "data" generated from a logit model fitted values and standard errors for tar-spot frequencies collected from the Turks and Caicos Islands.

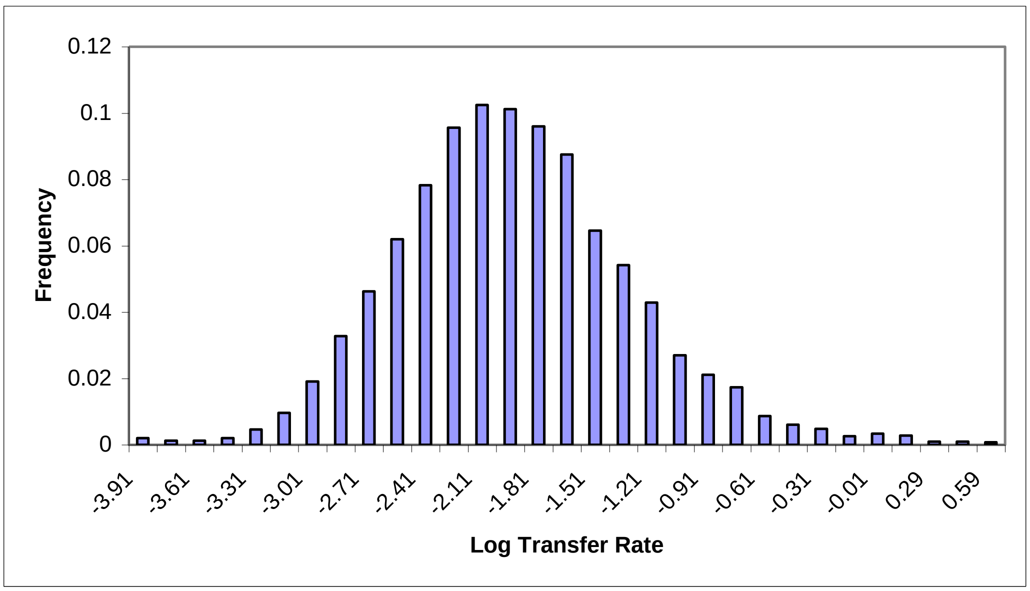

Figure 5: Simulation frequency showing a pattern close to a normal PDF. The mean and standard deviation were used for the transfer rate prior.

<u>10.3.3   Recruitment and Initial stock size</u>

The recruitment in each years and the initial stock size was based on the log-normal with mean and variance estimated from an assessment of the Turks and Caicos Islands spiny lobster stock, raised to levels consistent with the larger Bahamas area (see Table 4). The variance (CV) is scale invariant and therefore need not change.

The Caicos Bank recruitment and adult population was taken from the most recent previous stock assessment (CRFM 2007b; Medley and Ninnes 1997). The recruitment and adult population was estimated in numbers for the Caicos Bank and therefore was multiplied by the mean weight of lobsters in the catch to obtain the equivalent biomass for the Bahamas. The log estimates of the mean and standard deviation raised on the Bank area ratios was used for the priors (Table 6). This depends on two important assumptions:

1. Productivity of the areas is equivalent both in terms of recruitment and average biomass per square kilometer.

2. The state of the resources is comparable for the initial biomass of the Bahamas to be the same as the Caicos Bank.

The assumptions can be relaxed somewhat by increasing the standard deviation values. However, the Caicos Bank, being essentially another Bahamian Bank, and the high accuracy of the Caicos Bank assessment, suggest using the estimated standard deviation is appropriate. Given the poor data available for the Bahamas, it makes sense to apply greater control of parameter variation from the most reliable sources.

Table 6 Estimated recruitment and adult August biomass in each year for the Caicos Bank population model (CRFM 2007b).

	Recruitment (lbs)	Biomass	Adult Biomass (lbs)	
	Estimate	Ln	Estimate	Ln
MU	1369970	14.096	1574939	14.256
SD	341392	0.275	261347	0.174
Year				
1977	1847194	14.429	1103032	13.914
1978	1406326	14.156	1597278	14.284
1979	1519281	14.234	1676913	14.332
1980	1245552	14.035	1333153	14.103
1981	1670407	14.329	1043442	13.858
1982	885379	13.694	1329969	14.101
1983	1636200	14.308	1048610	13.863
1984	1342901	14.110	1431968	14.175
1985	1268875	14.054	1507880	14.226
1986	803597	13.597	1708538	14.351
1987	1040027	13.855	1480351	14.208
1988	904616	13.715	1480759	14.208
1989	930816	13.744	1470963	14.201
1990	1627085	14.302	1313160	14.088
1991	1844076	14.427	1566780	14.265
1992	1959576	14.488	1795921	14.401
1993	1510463	14.228	1813875	14.411
1994	1298640	14.077	1566382	14.264
1995	1389984	14.145	1517839	14.233
1996	1223447	14.017	1518716	14.233
1997	1301806	14.079	1651263	14.317
1998	1826014	14.418	1723451	14.360
1999	646125	13.379	2011314	14.514
2000	1613523	14.294	1476641	14.205
2001	1440646	14.181	1725267	14.361
2002	1094869	13.906	1728787	14.363
2003	1025853	13.841	1707657	14.351
2004	1724467	14.360	2031151	14.524
2005	1479507	14.207	2093609	14.554
2006	1591835	14.280	1793500	14.400

10.3.4 Natural Mortality

Natural mortality was fixed at 0.36 $year^{-1}$ with a small standard deviation of 0.0077, these figures were based on a Turks and Caicos Islands stock assessment (Medley and Ninnes 1997). The standard deviation is 10% of that estimated by Medley and Ninnes (1997), making this prior highly informative. Allowing greater freedom for this parameter led to an estimate of natural mortality and biomass which was much too high than realistically possible. By making this prior much more informative (effectively fixing M close to 0.36), a reasonable limit was being applied on a parameter which clearly could not be estimated from the data. The estimate of 0.35 $year^{-1}$ was suggested as typical for this species across the region by an expert working group assembled by FAO in 1998 (FAO 1998).

10.3.5 Uninformative Priors

Catchability was assumed uniform on the log scale for all gears and both recruit and adult segments. This prior is uninformative on these parameters, although a maximum and minimum log value was set to prevent unrealistic values which can cause problems in the numerical routines. These were a maximum of 1% and minimum of 10^{-8} % of the population size per unit of effort.

The observation error prior was based on the standard uninformative prior for the normal ($P(\mu, \sigma) \propto 1/\sigma^2$; see Gelman *et al*. 1995). The error is for the normal likelihood applied to the square root transformed catch estimated from the effort and population size.

10.3.6 Diagnostics and Model Fit

While the model fitted the data well (Figure 6), it did not explain much of the observed variation in CPUE (Figure 7). This was likely to be due, at least in part, to the cleaning process and poor quality of the data. A few outliers are also clearly evident in the residuals, although there are overall patterns over time, the variance does show some decrease perhaps due to improvements in the data (Figure 8). Convergence of the MCMC fitting method was tested using visual inspection of the MCMC parameters and simple diagnostic tools (see section 10.8). Further diagnostics should be obtained during the review process.

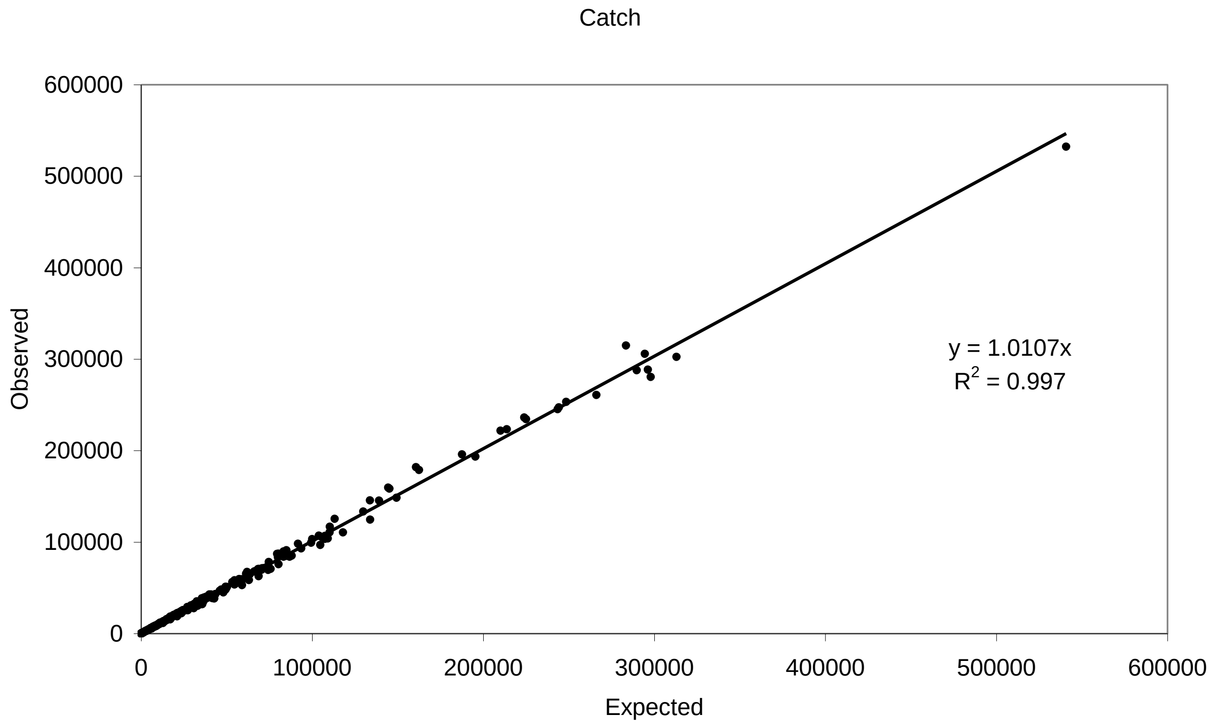

Figure 6: The observed and the (model generated) expected catch indicating the overall fit. The expected catch was generated by numerical integration using the MCMC procedure.

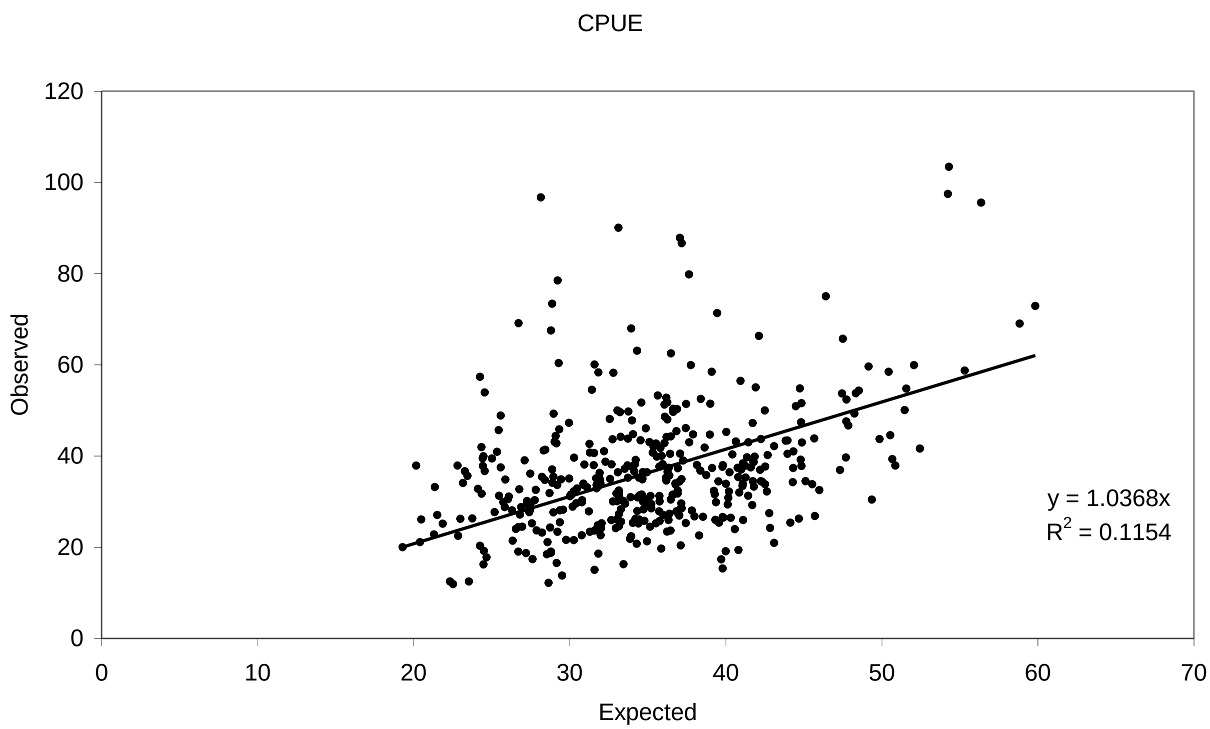

Figure 7: Relationship between the observed and expected catch-per-unit effort (CPUE). CPUE is the implicit abundance index, so the graph indicates the amount of variation in model stock size that explains the changes in observed CPUE.

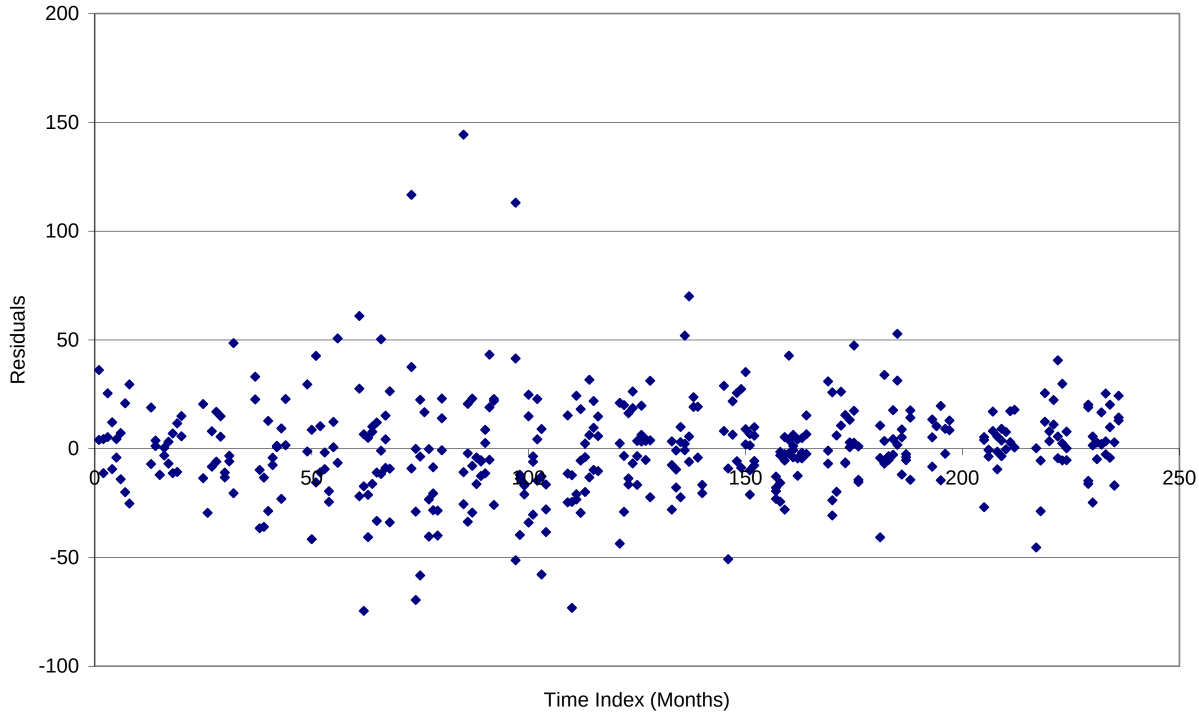

Figure 8: Model residuals plotted over time.

10.4 Precautionary Reference Points

Reference points based on MSY cannot be estimated reliably. Estimates of adult biomass at MSY were 0.21 of the unexploited biomass (Table 2). This is very low to be considered as a target reference point and would not be considered precautionary without good scientific evidence to support it. Such evidence is not currently available. However, the MSY based reference point would be a precautionary choice for a limit reference point.

Given the difficulties over stock identification and the source of recruitment, it appears most precautionary to apply internationally accepted reference points based on the unexploited stock size. The recommended values are outlined in Section 4. However, these may only be of limited use until current SSB and SSB_0 can be estimated reliably.

10.5 Harvest Control Rule

Management requires a decision rule which is set to determine when action might be taken to ensure the fishery is sustainable. The management plan should clearly define the principles on which the decision rules might be based. Stakeholders have a responsibility to agree the harvest control rule based on realistic controls (e.g. number of vessels, TAC, seasonal control). The rule would need to define under what conditions the fishery would close, and how the target state for the fishery would be approached and maintained.

Information on this fishery is not very reliable, and therefore precautionary levels of exploitation are recommended until more and better information is gathered on the state of the stock. While some level of safe catch can be determined from the data, reference points (MSY) cannot be accurately and safely determined.

The harvest control rules link stock size to levels of exploitation. As well as target exploitation levels, there should be a trigger below which exploitation is reduced such that the stock can rebuild. Limit, trigger and target reference points based on adult (mature) stock size defines the target and rebuilding exploitation levels.

Two controls seem possible: variable length closed season or an export quota. A variable length closed season may not be effective in controlling fishing mortality where fishing effort can be redistributed, so initial focus has been placed on developing an appropriate export quota.

A rule based on a simple statistic (CPUE) is proposed. It is unlikely a full stock assessment can be completed each year and therefore stock assessment outputs (e.g. estimated fishing mortality and SSB) are not appropriate for the decision rule. A moving average calculation of the August or annual CPUE can be used with reference points defined based on the CPUE which is implicitly linked to recruitment and adult biomass.

The following rules and issues have been suggested:

1. Target fishing mortality at or above the current level, based on the current best estimate of MSY. This can be converted to a fixed TAC or adjusted TAC based on recruitment estimate (August CPUE), or adjusted season length.
2. Limit exports (i.e. catch) to a maximum of 7 000 000 pounds of tails. This would involve capping landings by setting a total allowable catch administered by the processing companies. This is just below the maximum export observed in the available time series, and more precautionary lower levels may be warranted.
3. In both cases, the control would decline linearly from the trigger CPUE to the limit CPUE where no catches would be exported.
4. Other aspects, such as limitations on the variation in TAC from year to year, will need to be considered and tested based on the stock assessment.

These rules, although not currently applied, are used as the basis for projections to explore possible management options.

10.6 Projections

Projections were used to develop and test potential harvest control rules. Given the poor data and associated uncertainty, a harvest control rule should considerable improve the demonstrable sustainability of the fishery. Projections were run to 2008-2018 in all cases.

The CPUE index was generated for the projected harvest control rule using a simple random model emulating the model which was fitted to the observed data.

$$L_i = \left(\sqrt{\hat{L}_i} + \frac{\varepsilon_i \sigma}{\sqrt{f}} \right)^2$$

Where L_i= simulated observed CPUE, $\hat{L}$ = estimated CPUE from the population model, f=number fishing days that have been sampled, σ=estimated observation error standard deviation for the CPUE in the fitted model, ε_i= random error drawn from the standard normal probability. This CPUE estimate is then used to decide the TAC or other control for the year.

Where a limit on catches were applied as the control (TAC), the catches were distributed among the months and recruit/adult populations based on the mean observed catch among months, the mean estimated catch and catchability between recruits and adults of hook (condo) and spear diving. Traps now only catch a small proportion of the total catch and focus on adults, and therefore could be neglected.

The total catch in each year as determined by the HCR was distributed to each gear type and each month using the method applied for the population model and based on the average distribution observed in years for which data were available:

- The ratio of catches between trap and diving in the catch and effort data was used to split catches between diving and traps. This assumes that the trip interview sample represented the activity of each gear type.
- The monthly exports was assumed to relate to catches previously taken by adding 50% the catches of any month to its predecessor, excepting August (0% reallocated) and April (100% reallocated).

The mean catch for each month and gear, conditional upon the total exports, was then estimated using a simple least-squares multiplicative linear model. This was used to distribute the HCR catches among gears and months. The gear/month catch was then allocated between the recruit or adult population according to the ratio of estimated catchabilities for the gear.

10.7 Other Assessment Approaches

A number of assessments based on the commercial size category data have been carried out in the past (CRFM 2005, 2006, 2007a, 2008, 2009). These have generally tried to determine whether overfishing is occurring based on trends in CPUE and size composition. Size based methods have estimated very high absolute values for fishing mortality when selectivity for the diving gear is not allowed to be domed shaped. There are reasons to believe that larger lobster become increasingly unavailable to the dive fishery as they age and move into deeper water. However, how much of the high fishing mortality can be attributed to selectivity changes and how much to actual mortality is not clear, even in the current model. Therefore models which estimate selectivity, such as that used in the current assessment, tend to produce an optimistic assessment and models which assume fixed selectivity a pessimistic one. It is likely that the true state of the stock lies somewhere between. However, all available information suggests that fishing mortality has been increasing over the last two decades (Figure 9).

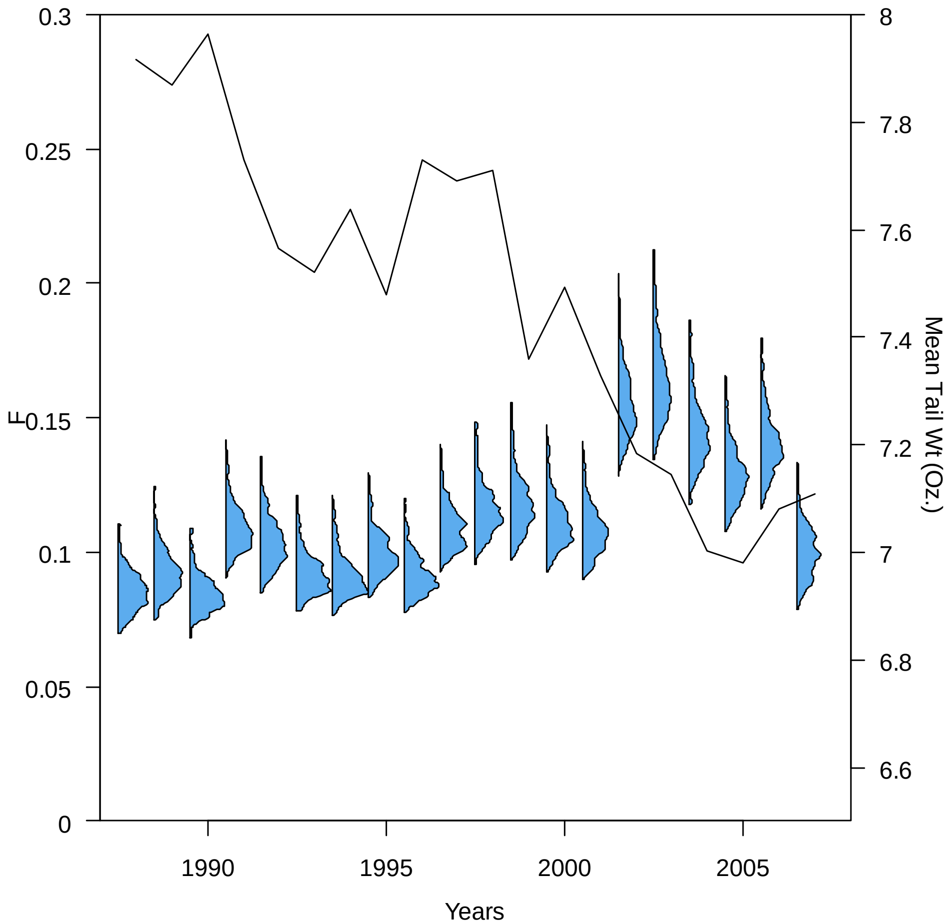

Figure 9 The estimated fishing probability density functions by year and the mean tail weight which can also be used as an indicator of fishing mortality. The decreasing trend in size corresponds to the overall increasing trend in fishing mortality in the catch-effort model.

In the current assessment, treating the population as undifferentiated (combining recruits and adults) did not fit the CPUE data well due to inconsistent patterns between trap and diving CPUE. Therefore, the population was split into juveniles that consist mainly of the new recruits each year, and adults which make up the spawning stock. Although growth is not explicitly modeled, growth rate estimates are used to estimate the transfer rate between juveniles and adults.

Various Biomass dynamics models, such as the Schaefer or Fox Models were not used. Recruitment is not easily linked to local stock size, and therefore it was believed that models explicitly estimating recruitment would fit the spiny lobster data better.

10.8 Fitting the Model

The posterior is calculated as the product of the prior and likelihood probabilities, or the equivalent sum of the log-likelihood and log-priors. In all calculations log values are used to avoid precision loss.

The model was implemented in MS Excel, which interfaced with R through RExcel (Table 7 and 8). This has some useful features, notably the ability to produce the same model in two formats which can be run against each other for testing purposes. It was verified that the results were the same in the two independently implemented models, suggesting no coding errors in the R model.

When fitting models using Bayesian techniques, there are limited options available. As in almost all cases the posterior probability density function (pdf) cannot be integrated directly, methods rely on being able to draw random samples from the posterior for Monte Carlo integration to calculate statistics of interest.

For high-dimensional problems (many fitted parameters), the favored choice is Monte Carlo Markov Chain methods (MCMC) (see Gelman *et al*. 1995). However, these methods can be slow to converge, as in this case, making practical implementation difficult. Best performance was obtained from an adaptive MCMC algorithm (Rosenthal 2007) implemented in the spBayes package in R (Finley *et al*. 2009). This method was used for the final fit. The adaptive method adjusts the tuning parameters for the jumping function based on the local acceptance/rejection of the new parameters which speeds up convergence. It should be noted that the method has no effect on the model or final result, but does improve the speed and accuracy of the fitted values. Various diagnostics were used to test for convergence (see below).

Monte Carlo techniques cannot be guaranteed to cover all the probability mass, and therefore some inaccuracy may result. By judicious choice of initial values and systematic searching across the parameter ranges, significant problems can be avoided.

The various data structures were set up using RExcel commands moving data from Excel to R.

Table 7 RExcel commands setting up the data structures for the analysis

RExcel Command	R Variable Name	Address	Values	Comment
rputdataframe	Catch	$D$16:$E$172	Total monthly catch data	
rputdataframe	CPUE	$I$16:$L$329	Catch and effort data	
rput	MuG	$D$4	-1.99	Log(G)
rput	ScaleG	$D$5	1.017676	1/(sqrt(2) sd(G))
rput	MuM	$D$6	0.03	M/month
rput	ScaleM	$D$7	1101.985	Scale M/month
rput	MuA	$D$8	17.58395	Log(Pop size)
rput	ScaleA	$D$9	4.060015	1/(sqrt(2) sd(S))
rput	MuRec	$D$10	17.42467	Log(Rec)
rput	ScaleRec	$D$11	2.572549	1/(sqrt(2) sd(Rec))
rput	Maxq	$D$12	-4.60517	Maximum log catchability
rput	Minq	$D$13	-46.0517	Minimum log catchability
rput	LnImpossible	$D$14	-9999999	Marker for impossible outcomes
rput	vnames	$M$29:$M$53	Parameter names	
rput	P	$O$29:$O$53	Initial parameter values	
rput	TuneP	$P$29:$P$53	MCMC tuning parameters	

Table 8: Initialization code and R function used to calculate the posterior.

<table>
<tr><th>R Code</th><th>Comment</th></tr>
<tr><td>CPUE$LandedLbs <- sqrt(CPUE$LandedLbs)</td><td>Initialization code for the landed catch transform</td></tr>
<tr><td>Post <- function(P) {</td><td>POSTERIOR FUNCTION</td></tr>
<tr><td>Plen <- length(P)</td><td>Number of parameters</td></tr>
<tr><td>M <- exp(P[1]) ; G <- exp(P[2])</td><td>Nat mort and Transfer</td></tr>
<tr><td></td><td>PRIORS</td></tr>
<tr><td>if ((P[12] <= 0) || any((P[3:10] < Minq), (P[3:10] > Maxq)))
{return(LnImpossible+1) }</td><td>Check parameter bounds: Sigma must be greater than zero</td></tr>
<tr><td>SumSq <- (ScaleM*(M - MuM))^2</td><td>Natural Mortality</td></tr>
<tr><td>SumSq <- SumSq + (ScaleG*(P[2]-MuG))^2</td><td>Transfer</td></tr>
<tr><td>SumSq <- SumSq + (ScaleA*(P[11]-MuA))^2</td><td>Initial adult</td></tr>
<tr><td>SumSq <- SumSq + sum((P[13:plen]-MuRec)^2)
* ScaleRec*ScaleRec</td><td>New recruits</td></tr>
<tr><td></td><td>MODEL</td></tr>
<tr><td>ExpM <- exp(-M)</td><td>Set up rate constants</td></tr>
<tr><td>ExpMd2 <- exp(-M*0.5)</td><td></td></tr>
<tr><td>ExpMG <- exp(-M-G)</td><td></td></tr>
<tr><td>G_I_ExpG <- G * (1-exp(-M-G))/(M+G)</td><td></td></tr>
<tr><td></td><td>Set up parameters and data vectors</td></tr>
<tr><td>Tslen <- length(Catch$Diving)+1</td><td>time series length</td></tr>
<tr><td>Recruits <- rep(0, Tslen) ; Adults <- Recruits</td><td>Population size vectors</td></tr>
<tr><td>Rq <- exp(P[3:6]) ; Aq <- exp(P[7:10])</td><td>Set up q arrays : DC 1 ; DS 2 ; TL 3 ; TF 4</td></tr>
<tr><td>PropDiveCatchRec = 0.5*(Rq[1]/(Rq[1]+Aq[1]) +
Rq[2]/(Rq[2]+Aq[2]))</td><td>Proportion of the dive catch which are recruits</td></tr>
<tr><td>PropTrapCatchRec = Rq[3]/(Rq[3]+Aq[3])</td><td>Lobster traps only. Fish traps are not used for selectivity as minor component of the catch</td></tr>
<tr><td>RecCatch <- PropDiveCatchRec*Catch$Diving +
PropTrapCatchRec*Catch$Trap</td><td>Catch attributed to the recruits</td></tr>
<tr><td>AduCatch <- Catch$Diving+Catch$Trap-RecCatch</td><td>Catch attributed to the adults</td></tr>
<tr><td>RecCatch <- RecCatch*ExpMd2</td><td>Correct the catches for mid month</td></tr>
<tr><td>AduCatch <- AduCatch*ExpMd2</td><td></td></tr>
<tr><td></td><td>POPULATION MODEL</td></tr>
<tr><td>Rec <- 0.0 ; Adu <- exp(P[11]) ; Ti <- 1</td><td>Initialize Population, time index and Error scale</td></tr>
<tr><td>For (yi in 13:plen) {</td><td>For each year based on the recruitments in the parameter list</td></tr>
<tr><td>Rec <- Rec+exp(P[yi])</td><td>Add new recruits</td></tr>
<tr><td>for (mi in 1:12) {</td><td>for each month</td></tr>
<tr><td>Recruits[Ti] <- Rec</td><td></td></tr>
<tr><td>Adults[Ti] <- Adu</td><td></td></tr>
<tr><td>Adu <- Adu*ExpM + Rec*G_I_ExpG - AduCatch[Ti]</td><td>Adult Population</td></tr>
</table>

`Rec <- Rec*ExpMG-RecCatch[Ti]`	Recruited Population
`Ti <- Ti+1`	
`if (is.na(Rec)||is.na(Adu)||(Rec <= 0) || (Adu <= 0)) { return(LnImpossible+2) }`	
`} #for mi`	
`} #for yi`	
`Recruits[Ti] <- Rec`	
`Adults[Ti] <- Adu`	Last month population
	LIKELIHOOD
`Ecatch <- sqrt((Rq[CPUE$Gear]*Recruits[CPUE$TimeIndex] + Aq[CPUE$Gear]*Adults[CPUE$TimeIndex] ) * CPUE$DaysFishing)`	Sq root of expected catch
`SumSq <- SumSq + sum((Ecatch - CPUE$LandedLbs)^2) / (2*(P[12]^2)) + log(P[12])*(length(Ecatch)+2)`	Likelihood for the catch. Includes sigma prior as sigma^(-2)
`Return(-SumSq)`	
`}`	

R commands to run the adaptive MCMC algorithm were taken from the spBayes package (Table 9). In this case, there is no automatic "burn-in" or thinning which could otherwise reduce memory use. The random seed can be set to alternative values to produce different streams of random numbers. Once the data are converted to a MCMC object, various standard functions are used to generate diagnostics to test for convergence. The model is slow to converge and therefore a larger number of draws were taken to obtain better estimates of the posterior. While the results were adequate, estimates could clearly be improved. Future improvements might be obtained by combining runs from different start points, not using only the posterior mode, and starting the procedure with tuning parameters estimated from previous runs.

Table 9: R code used to run and test the MCMC. The routines require the previous set up in R and RExcel. In order to confirm that a minimum convergence was achieved for each parameter, the simulation values were also visually inspected using Plot().

R Code	Comment
`library(spBayes)`	Installs the spBayes library
`set.seed(1)`	Optional for random numbers
`PostSamp <- adaptMetropGibbs(ltd=Post, starting=P, tuning=TuneP, batch=600, batch.length=50,report=500)`	Calls adaptive MCMC sampling to generate 600*50 draws
`PostDraw <- mcmc(PostSamp$p.samples[10000:nrow(PostSamp$p.samples),])`	Converts draws to mcmc object, ignoring first 10000 as burn-in
`autocorr.diag(PostDraw)` `autocorr.plot(PostDraw)`	Produce correlation diagnostics
`geweke.diag(PostDraw)`	Tests for convergence

The graphical outputs were generated in Excel, and in R and Visual Basic using the R Grid package. Code is available from paulahmedley@yahoo.co.uk on request.

10.9 Recommendations

Improve estimates of catch and catch-effort time series. The primary problem for the stock assessment is the relatively poor data available. Total annual exports are recorded reasonably accurately, but when these catches are actually taken within the year has to be estimated. In addition, there are catches which are not exported and which should be estimated and included when possible. These locally consumed catches will need to be estimated as a time series to have any impact on the stock assessment.

The catch and effort data are based upon trip interviews. Some of these data are clearly erroneous either in collection or recording in the database. Fishing effort in particular has not been recorded accurately. Quality control of these data has been poor and, in particular, quality of effort data for some of the mother-ship operations needs to be improved. If the harvest control rule depends on catch and effort data, it is a very high priority that these data be improved. Improvements should be seen with the EU Catch Certificate system.

Implement a stock assessment review process. This stock assessment must undergo peer review. This would be most easily and cost-effectively done using the CRFM Conch and Lobster Working Group which should meet in June of each year. The review should carry the following tasks:

- Oversee the overall quality of the assessment, including checking for simple errors, such as coding errors and incorrect data through examining residuals and outliers etc.
- Consider whether the model assumptions and structure are reasonable. If the model structure can be significantly improved, implement the improvement as part of the assessment.
- Identify an appropriate base case and sensitivity analyses. Request and review all output necessary to verify the model fit, diagnose problems and be able to give management advice.
- Identify the main axis of uncertainty and bracket the interval which will cover the true fishery state with a high degree of certainty.
- Provide full management advice, taking account of the uncertainty, based on the best scientific assessment available. The management advice may require evaluation of management tools such as harvest control rules, indicating whether they are precautionary and robust to uncertainties identified as part of the assessment process.

Include Size Composition Data into the Assessment. Assuming that the current catch and effort data are considered acceptable, including size composition should allow the assessment to model the population components. However, the limitations on the size data (i.e. sizes based on weight and inconsistent sizes used in commercial size categories) would make such a model far from easy to complete.

Assessments for the Separate Bank Populations. The stock assessment cannot separate the different lobster populations in the Bahamas because the catch data cannot be attributed to any particular location. Strictly speaking, adult stocks should be managed separately, and as data improves, separate assessments for each area should be undertaken.

11. References

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Appendix 4: Report of the Small Coastal Pelagic Fish Resource Working Group (SCPWG)

Consultant: Professor Juan Carlos Seijo

Chairperson: Maren Headley

Group Members: Dr. Susan Singh-Renton (CRFM Secretariat); Ms. Ruth Redman (Trinidad & Tobago); Mr. Mauro Gongora (Belize); Ms. Elizabeth Mohammed (Trinidad & Tobago); Mr. Ricardo Morris (Jamaica); Professor Hazel Oxenford (CERMES); Mrs. Anginette Murray (Jamaica); Mr. Sam Heyliger (St. Kitts & Nevis); Mr. Alwyn Ponteen (Montserrat); Ms. Elaine Ferrier (CIDA)

A. Overview

1. Review and Adoption of Meeting Agenda
   The group reviewed and adopted the proposed agenda.

2. Review of Meeting's Objectives
   It was agreed that the main objectives of this year's meeting would be to:
   (i) To explore the bioeconomic dynamic impacts of managing the multi-fleet & multispecies flyingfish fishery.
   (ii) To undertake risk analysis of alternative fishery management decisions.

3. Review of Working Group's Commitment to the CLME Project
   An overview of the Flyingfish Pilot component of the CLME project was provided. The Caribbean Large Marine Ecosystem (CLME) project is a four year Global Environment Fund (GEF) project to promote the sustainable management of the shared living marine resources of the region through an integrated or ecosystem-management approach (CRFM 2010; UNDP 2010). The overall coordination for this flyingfish pilot will be provided by the CRFM Secretariat.

   The following priority actions for the sustainability of the Eastern Caribbean flyingfish fishery have been identified under the CLME Flyingfish Pilot project:
   (i) Improvement of data availability and information including catch / effort information, in the Eastern Caribbean taking into account long lining and mixed landings;
   (ii) Bioeconomic studies of the fishery to establish the bioeconomic criteria and set reliable management measures for the fourwinged flyingfish;
   (iii) Assessment of species interaction between flyingfish and large pelagic fishes to provide for these in management using EBM principles; and
   (iv) Assessment of economic risk and social impacts to refine the management for the fourwinged flyingfish.

4. Review of available new data and information on fishery interest, including review of national reports, fisheries trends, pertinent technical studies completed to date and management developments.

A brief overview of the flyingfish fisheries in the region was provided including trends in landings and the value of the fisheries in the Eastern Caribbean.

An update on the status of the flyingfish fishery in Tobago was provided by the national representative. It was reported that only one company was currently processing flyingfish and fishers were not targeting flyingfish as much as in previous years given the lack of a market. The meeting was also informed that many of the individuals who received training in deboning flyingfish, which adds considerable value to the product have left the processing sector and sought alternative employment.

An inter-sessional study completed by the CIDA intern Ms. Elaine Ferrier, was presented to the group. The study was focused on obtaining the perspectives of stakeholders on the importance of various management objectives. A summary of the findings is provided below.

Regional governance of the flyingfish fishery in the Eastern Caribbean requires agreement upon management objectives as well as how important these objectives are in relation to each other. A pre-established hierarchy of objectives can guide governance of the fishery and significantly assist decision-making processes. This hierarchy is critical to manage the complexity of a multi-species regional fishery, because it is rarely possible to optimize multiple and competing objectives (Pope 1997 as cited in Mardle *et al.*, 2004).

Field work was conducted with fishers, fish processors, and fisheries division staff in Barbados and Tobago to determine their perception of the relative importance of a range of management objectives drawn from FMPs and reports relating to the Eastern Caribbean Flyingfish fishery. Thirty seven respondents from eight landing sites conducted a modified pairwise comparison technique developed by Simos (1990, as described in Ondrus and Pigneur 2006) which involved sorting cards with a description of each management objective. In this technique, respondents were asked to arrange the cards according to their importance from 1 to *n*. This ordinal data was then converted into pairwise comparison tables. That is, if a respondent sorted objective A as more important than objective B, objective A was recorded as being more important in the pairwise comparison. Note that this assumes that by positioning a card in a certain level, the respondent believed this card to be more important than all those below it, less important than all those above it, and of equal importance to those in the same level.

The management objectives drawn from FMPs and grey literature reports and their relative weights as determined in the study are as follows (Figure 1):

16.2% Sustaining the stock size

- Ensuring that there are Flyingfish available for future generations
- Preventing overfishing to maintain a healthy stock

10% Accurate information

- Ensuring that an effective data collection system is in place to provide accurate information and knowledge about the state of the fishery

10.1% High profits

- Optimal economic benefits for all involved in the fishery

10.3% Effective management

- Ensuring that there is an effective system for management and enforcement to management as needed
- Effective management is adaptive, responsive to changing information about the fishery, and involves stakeholders in decision-making

7.4% Affordable food source

- Ensuring that Flyingfish remains an affordable and available source of food for the future

7.6% Balanced ecosystem (balanced trophic levels)

- When something is removed from the ecosystem, we know that it has an effect on other species and ecosystem processes.

10% Successful processing and export market

- Developing the post-harvest production and export of Flyingfish

7% Resilience to environmental change

- Ability to withstand the effects of climate change, extreme weather events and other environmental changes

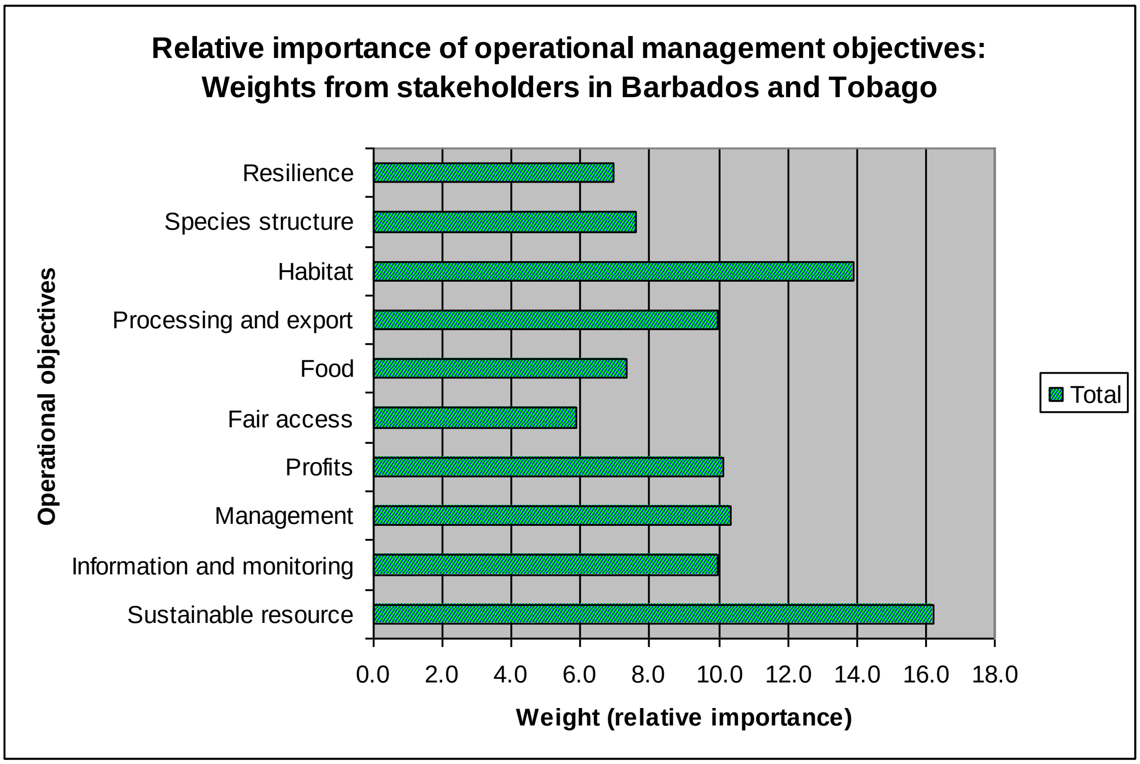


Figure 1: Relative importance of operational management objectives: weights from stakeholders in Barbados and Tobago.

B. Fishery Report

1.0 Eastern Caribbean Flyingfish Fishery

1.1 Management Summary

1.1.1 Policy and Objectives

Regional Flyingfish Policy

Regional policy relating to flyingfish in the Eastern Caribbean is currently under development. In 1999, an Ad Hoc Working Group was assembled by the FAO to compile existing data and develop regional policy and management strategies. The following policy statement was developed in 2008 at the third meeting of this group:

"The objective of fisheries management and development shall be to ensure responsible and sustained fisheries, such that the fisheries resources in the waters of the eastern Caribbean are optimally utilized for the long-term benefit of all people in the eastern Caribbean region."

More specifically, the working group articulated the following operational objectives for the flyingfish fishery (FAO 2010; paraphrased and headings added):

Management
- Collaborative management
- Fair access to the fishery
- Distribution of benefits to all people in the region
- Active fisherfolk organizations with effective links to other organizations and governments

Harvest sector
- Well trained fishers
- Investment in the fishery
- Commitment to responsible fishing practices
- Access to reasonably priced fishing equip and supplies, stable market

Post-harvest sector
- High quality fish and fish products
- Prevention of wastage
- Greater distribution of profits
- Value-added (processed) products
- Better distribution of fish products to all sectors of the local public

1.1.2 Fisheries Management

Flyingfish Management

There are currently no management rules or controls for the Flyingfish fishery in the Eastern Caribbean. In lieu of formal reference points for the Flyingfish fishery, a stock assessment conducted in 2008 identified an annual harvest trigger point of 5,000 tonnes, indicating that:
"Sustained catches at, or above, this level are likely to bring about an unacceptable risk of overfishing. Either catches must be maintained below this level, or further research, data collection and stock

assessment work is required to enable a new higher limit to be set while still ensuring that the limit is safe" (Medley *et al.* 2008).

Table 1: The feasibility of various future management actions for Flyingfish and the limitations (FAO, 2010)

Type of Control	**Control**	**Constraints**
Output controls	Total allowable catches (TACs) or individual quotas (IQs)	Allocation of allowable catch among countries would be contentious and difficult. Setting a TAC for the duration of the season may result in overcapitalization of the stock at the beginning of the season. Setting quotas for periods within the season or allocating IQs may be a way around this problem. However a TAC or IQ approach requires a standard of monitoring that is beyond the capacity of most or all countries, and would be even more challenging at the regional level. An advantage to this approach is that it can be modified each year if managers are able to use catch data to predict future abundance.
	Size limits	Not relevant for several reasons: Flyingfish do not continue to grow once they mature; the fishing technique targets spawning fish, which are mature; and the gill net is a standardized size which targets mature fish and is therefore size-selective. Would require an impractical amount of monitoring to enforce size of catches.
Input controls	Limited licensing	Licensing would be challenging due to the complication of determining a standard unit of effort for the many different types of boats. In addition, allocation of licenses among stakeholders within the region would be contentious and difficult. Despite these challenges this approach is "probably the most appropriate tool at this time".
	Closures	Closures may be appropriate, yet because there are two distinct spawning periods, the timing of the closure would be dependent on whether these two spawning periods indicate the presence of two Flyingfish stocks. If there are two stocks, then two closures during both spawning periods would be necessary to protect both stocks. Alternate possibilities include having several closed periods throughout the season or alternating the timing of the closure from year to year. Implementation of closures would be challenging to the uncertainties about stock dynamics. In addition, while not mentioned in the report, a further complication is the linkage to large pelagic fisheries through the extensive use of Flyingfish as a bait fish.
	Bag limits (limiting individual or boat to catching a certain amount of fish per trip)	Not practical for Flyingfish because it would require surveying catches from each boat for each trip, and this is far beyond the current monitoring capacity of fisheries departments. Catches are extremely variable because Flyingfish spawn in large but unevenly distributed schools. As a result catch rate per day varies enormously from day to day depending on whether a school was encountered.
	Gear limits	Regulating mesh size of gillnets is irrelevant because Flyingfish grow very little after they mature. Regulating FADs may be appropriate because they are often covered in eggs from fish spawning around them. Wasting these eggs by bringing FADs to shore could have negative implications for recruitment.
	Monetary	Monetary incentives or disincentives are crude and unlikely to be acceptable.

1.2 Status of Stocks

1.2.1 Flyingfish (*Hirundichthys affinis*)

Estimates of annual total flyingfish landings for the eastern Caribbean are available in FAO (2010). The landings, estimated for Barbados, Trinidad and Tobago, St Lucia, Grenada, St Vincent and the Grenadines, Dominica and Martinique vary considerably from year to year. These estimated landings ranged from 1,025 to 2,523 tonnes per year between 1950 and 1979 and appeared to increase thereafter, ranging from 2,121 to 4,725 tonnes per year between 1980 and 2007 (Figure 2). The estimated average annual landing between 2002 and 2007 was 2,512 tonnes. These data are, however, to be treated cautiously as they are likely underestimates of the true catches in the region. Grenada has developed a significant bait fishery for the species, the catches of which are not well documented. In addition, landings from Martinique and other countries in the Eastern Caribbean likely to be harvesting the species are not available. There are also gaps in available data which required interpolation to estimate landings for years without data. Generally several countries lack a clear methodology for estimating total catches from recorded data. Consequently, there is tremendous uncertainty in the level of historical catches of flyingfish for the Eastern Caribbean. Estimates of fishing effort are also uncertain.

Three stock assessments of the flyingfish fishery within the Eastern Caribbean have been conducted (Mahon 1989; Oxenford *et al*., 2007; Medley *et al*., 2008) and extensive research undertaken on the fishery by the Eastern Caribbean Flyingfish Project (Oxenford *et al*., 2007). In addition, a preliminary trophic model constructed for the Lesser Antilles Pelagic Ecosystem (LAPE) project examined impacts of predator-prey and technological interactions in the fishery (Mohammed *et al*., 2008a) and a preliminary bioeconomic model for the eastern Caribbean flyingfish fishery was developed (Headley, 2009).

The most recent stock assessment (Medley *et al*., 2008) considered a wider spatial range of landings data than the previous assessments (Barbados, Trinidad and Tobago, St Lucia, Grenada, St Vincent and the Grenadines, Dominica and Martinique) for 1955 to 2007 and catch and effort data from Barbados, Trinidad and Tobago and Saint Lucia from 1994 to 2007. A Beverton and Holt Stock Recruitment model was used with the possible oceanographic effects on the population accounted for by inclusion of process error in the analyses and uncertainties in biological parameters accounted for using a Bayesian approach. ***The stock assessment suggested that the stock of flyingfish in the eastern Caribbean is not overfished and that overfishing is not occurring.***

The assessment, however, could not be used to determine whether or not "local depletion" may be occurring as the data are not available in the level of detail required to do so. Catch rates have remained fairly stable even with increased overall catches. Given the potential stock area, and estimates of a relatively large stock size from tagging and survey data, it is unlikely that the catches have ever exceeded the maximum sustainable yield from the stock. Consequently, there is no evidence that the stock has ever been overfished.

The model estimated, for 2007, MSY at between 3,312 and 36,291 tonnes; B/Bmsy at between 1.97 and 4.17; and F/Fmsy at between 0.03 and 0.5 (0.05 and 0.95 confidence intervals respectively). The model projections show that keeping the fishing effort and capacity or catch at about 2,500 tonnes (the maximum recorded catch to date has been 4,700 tonnes) should be safe with overfishing very unlikely even with stock fluctuations due to environmental influences. Given the uncertainty in the MSY value, attempts to fix the fishing mortality in relation to MSY or set catches at or above 5,000 tonnes led to prediction of significant risks in overfishing. Consequently, it was suggested that a trigger point should be established at 5,000 tonnes, such that when catches consistently exceed this figure management should take action to safeguard the stock from overfishing.

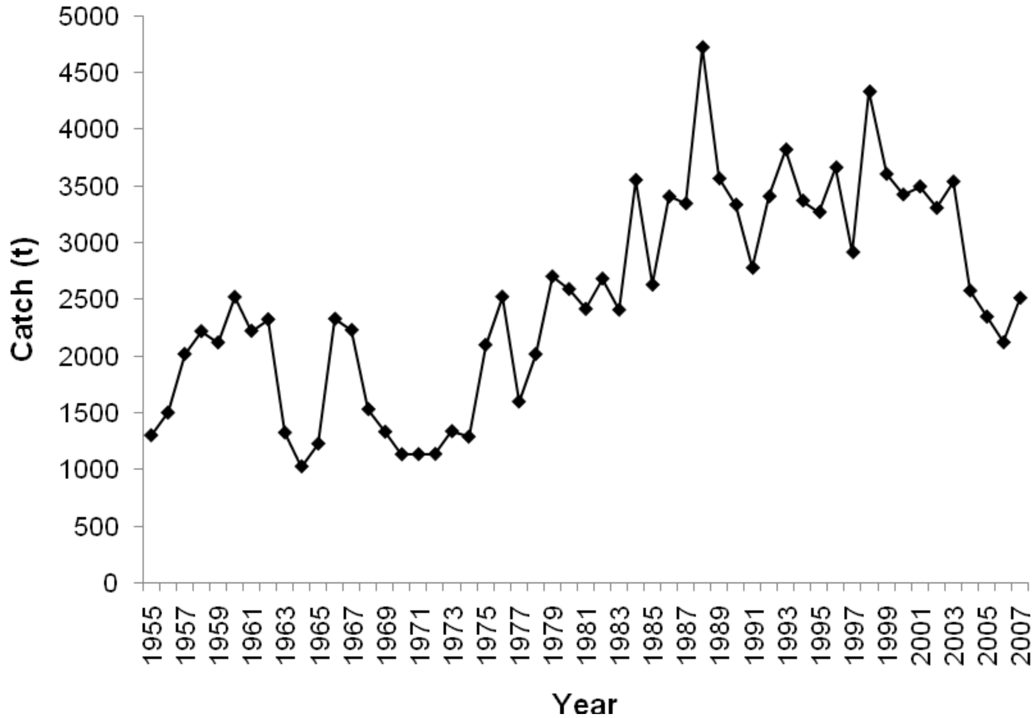


Figure 1: The estimated total catches of flyingfish from the Eastern Caribbean stock (1955-2007).

1.2.2 LAPE-flyingfish/dolphinfish interactions

A trophic model using Ecopath with Ecosim software was developed for the Lesser Antilles Pelagic Ecosystem (LAPE - an estimated area of 610,000 km^2 including the Exclusive Economic Zones of all the islands from Antigua and Barbuda and St. Kitts/Nevis in the north to Trinidad in the south, excluding the Gulf of Paria) representing an average year between 2001 and 2005 (Mohammed *et al*., 2008a) under the FAO Lesser Antilles Pelagic Ecosystem Project. Due to severe data limitations the model drew on inputs from other models constructed for the LAPE region, central Atlantic region, Florida shelf ecosystem, central Pacific Ocean and the British Virgin Islands reef ecosystem as well as new information (diet composition and biomass estimates of some species, primary production, fisheries catches) generated by the Project or in the published literature.

The data inputs included average catches between 2001 and 2005 disaggregated by eight defined fleet types (Mohammed *et al*., 2008b), estimates of total mortality or the ratio of production to biomass, consumption rates and biomass (Mohammed et al., 2008a) as well as estimates of diet composition (Heileman *et al*., 2008). Thirty-one functional groups were defined with flyingfish and dolphinfish representing explicit groups. The model was balanced by solving simultaneous linear equations describing production, consumption, fishery removals, other mortality, net migration and biomass accumulation for all groups in the system to satisfy the two Ecopath master equations after Christensen *et al.* (2000) and adjusting input parameters where necessary based on consultation with regional experts.

The balanced model, which represents one of several possible representations of the biomass flows in the ecosystem, gave an estimated biomass of 126,880 tonnes for flyingfish and 16,958 tonnes for dolphinfish, assuming homogeneous distribution throughout the LAPE area. The estimated base fishing mortality of flyingfish was 0.013 year^{-1}; predation mortality was 3.787 year^{-1} and other mortality 0.2 year^{-1}. Flyingfish experienced greatest predation mortality from dolphinfish (1.15 $year^{-1}$), large mesopelagics (1.11 $year^{-1}$), large squids (0.74 $year^{-1}$) and coastal predators (0.52 $year^{-1}$). For dolphinfish, the estimated base fishing mortality was 0.13 $year^{-1}$, predation mortality was 4.394 $year^{-1}$ and other mortality was 0.196 $year^{-1}$. Dolphinfish experienced greatest predation mortality due to cannibalism (4.32 $year^{-1}$) compared to predation by bigeye tuna (0.023 $year^{-1}$ and yellowfin tuna (0.016 $year^{-1}$). A preliminary simulation using Ecosim examined the impacts of increased fishing mortality on flyingfish from the baseline to F = 1.0 $year^{-1}$ at year 5, and sustained at this level for an additional 15 years showed that dolphinfish, as a key predator of flyingfish, is negatively impacted. However, when dolphinfish is subject to a similar pattern in fishing mortality the increases in flyingfish biomass were modest. A combined increase in fishing mortality of the two groups was detrimental to dolphinfish. ***The inequality in responses to increased fishing on flyingfish and dolphinfish suggests that prey availability is a stronger control in the dolphinfish – flyingfish dynamics, than predator control.***

The authors caution about the limitations of the model, including its non-validation and advised that the model be considered a framework for critical analysis which can be used to assess the compatibility of new and existing information for the region, to develop hypotheses about the biological and technical interactions within the LAPE and to identify research needs for understanding these interactions and their relevance to management.

Fanning and Oxenford (2011) extracted outputs of the trophic model (Mohammed *et al*., 2008a) to describe the trophic, technical and economic linkages between dolphinfish and flyingfish, and among the longline, beach seine and traditional flyingfish fisheries and to highlight the management concerns that are of relevance to implementing an ecosystem approach to fisheries. In concluding, the authors noted that single species assessments of both species, each of which is annual, based on their respective life history characteristics have suggested that each stock can withstand relatively high levels of fishing effort with little risk of stock collapse but that when the trophic linkages are quantified it becomes apparent that the dolphinfish population is highly sensitive to flyingfish biomass, and the respective fishery is less likely to be sustainable with a marked decrease in flyingfish biomass. The authors recommended that the quality and quantity of catch and economic data be improved and that basic biological research, in particular diet studies, be conducted to improve the model quality as a basis for its use in assessing ecosystem level changes over time.

1.3 Management Advice

Given that stock fluctuations and climate change effects can negatively affect the abundance of flyingfish, the following management considerations are suggested:

1. Strengthening, through education, fishing community resilience and adaptability to fluctuating stocks and changes in resource accessibility,
2. Fostering vessel malleability and versatility to facilitate shifting of target species as required by stock fluctuations and climate changes effects on species distribution and availability and over space and time,
3. Fishing licensing, for this fishery should be for multiple species rather than for single species. This would allow fishermen to react intelligently to relative stock abundance/availability and associated profits over time.

1.4 Statistics and research recommendations

1.4.1 Recommendations for the Caribbean Regional Fisheries Mechanism Secretariat

Future bioeconomic research for this important fishery of the CLME, should perhaps consider the following questions:

1. Are long-term stock fluctuations associated to changes in abundance of predators (i.e. dolphinfish, and other large pelagic species) and competitors targeted by other fleets? If so, is there a dynamic bioeconomic optimum level of effort and fishing capacity of the eco-technological interdependent fleets?
2. Are the cycle and/or amplitude of long-term fluctuating stocks changing with climate change? If so, what should the adequate vessel capacity be?

In order to address the questions listed above, biomass estimates for the important commercial pelagic species harvested in the multi-species flyingfish fishery will be necessary to incorporate in the analysis their dynamics and corresponding ecological interdependencies.

1.4.2 Individual Countries

Countries should consider conducting a cost survey of their multi-species pelagic fleets, which would allow the economic data to be updated.

1.5 Stock Assessment Summary

This assessment explored the bioeconomic dynamic impacts of managing the multi-fleet and multispecies flyingfish fishery, and undertook risk analysis of alternative fishery management decisions. Some of the management questions considered in the analysis of this stock fluctuating fishery involved the following questions:
1. Can this stock fluctuating fishery be managed sustainably with an open access strategy?
2. Which is the bioeconomic optimum fishing mortality and corresponding vector of catch quotas for managing a stock fluctuating fishery?
3. Which are the risks of falling below limit reference points associate to alternative fishery management strategies?

For the identified management questions, and corresponding performance variables:
1. A dynamic model was built with and without fluctuating carrying capacity.
2. Bioeconomic parameters were calculated from data provided by participants' countries and relevant published previous fishery assessments.
3. Without fluctuating carrying capacity, as suggested by Klyashtorin (2001), the flyingfish pelagic fishery model did not represent the dynamics of observed catch.
4. Optimal control theory was applied to estimate the cycle and amplitude parameters that best fitted the trajectory of observed catch data, and the optimum fishing mortality (Fopt) to be multiplied over time by the fluctuating biomass to obtain a dynamic TAC.
5. Proceed to explore alternative management strategies to address the management questions and their effect on B_t, Y_t and NPV.
6. A Monte Carlo analysis was undertaken to estimate the probability of exceeding biologic ($B(OA)_t/K_t$) and economic LRP's (NPV(OA)/NPV(TACopt) with alternative management strategies. A risk analysis to estimate tables without mathematical probabilities were built using alternative criteria involving different degrees of risk aversion.

The main results of this preliminary dynamic bioeconomic analysis are the following:
1. The biomass dynamics for this stock fluctuating fishery using a dynamic carrying capacity with an expanded version of Schaefer-Gordon model with multispecies and multi-fleet built in reflects adequately the trajectory of catches for the period 1950-2007.
2. Under open access, harvest rates in the neighborhood of 5000/year ton could result in temporary collapse of this pelagic fishery. This could be prevented with catch quotas, tending to the

TACopt, are established and effort is controlled to reduce exploitation rates by 30% to allow the resource to recover its natural fluctuations over time.

3. The multi-species nature of this fishery involves additions to the flows of revenues to the fishery over time coming from the harvest of valuable large pelagic species like dolphinfish, tunas, and wahoo, among others. Therefore, under open access, fishermen will not react by reducing their effort when encountering lower biomass levels of flyingfish because the other species harvested will tend to cover the variable costs of the fishing trip. Also, it was pointed in the discussions of the working group that price of flyingfish has is very seasonally sensitive to supply (harvest rates over time), tending to reach substantial increases in price with low catch rates. This effect not explored in the quantitative analysis will tend to accentuate the need for managing the fishery with the input and output control measures mentioned above.
4. Monte Carlo analysis indicates that with the current exploitation rates there is no risk of exceeding a 0.3 ratio of Bt/Kt.
5. It was estimated in the Monte Carlo analysis that the net present value of the flow of profits was in the neighborhood of 63% of the profits that could be obtained if operating the fishery at Fop.

1.6 Special Comments

None.

1.7 Policy Summary

Regional policy relating to flyingfish in the Eastern Caribbean is currently under development. In 1999, an Ad Hoc Working Group was assembled by the FAO to compile existing data and develop regional policy and management strategies. The following policy statement was developed in 2008 at the third meeting of this group:

"The objective of fisheries management and development shall be to ensure responsible and sustained fisheries, such that the fisheries resources in the waters of the eastern Caribbean are optimally utilized for the long-term benefit of all people in the eastern Caribbean region."

1.8 Scientific Assessments

1.8.1 Background

1.8.1.1 Flyingfish (*Hirundichthys affinis*) Biology

There are at least 13 species of the flyingfish (Exocoetidea) occurring in the eastern Caribbean, of these only three (3); *Hirundichthys affinis*, *Cypselurus cyanopterus* and *Parexocoetus brachypterus* are known to be commercially exploited (FAO, 2010). The fourwing flyingfish (*Hirundichthys affinis*) represents the most important species accounting for approximately 99 percent of all flyingfish landings within the region (FAO, 2010).

Aspects of the biology of *H. affinis* in the eastern Caribbean have been extensively studied and there are several comprehensive reviews (e.g. Lewis *et al*., 1962, Storey, 1983; Hunte *et al*., 2007; FAO, 2010). Here we pull from those reviews and summarize key aspects of their biology, relevant to this assessment.

H. affinis is a relatively small epipelagic species having a maximum mean standard length (SL) of around 25 cm (mean size taken by the fisheries is around 20-22 cm SL) (FAO, 2010). It is a short-lived (annual) species with a maximum age of around 18 months (Campana *et al.*, 1993). Initial growth is very fast throughout the first six (6) months where it may reach fork lengths (FL) of around 19 cm (FAO, 2010).

This rapid growth then slows dramatically after reaching sexual maturity at about 20.3 cm FL after about 5 - 7 months (Storey, 1983), after which an individual may grow on average to approximately 23 cm FL at 12 months and a maximum of 25 cm FL at 18 months (Oxenford *et al.*, 1994; FAO, 2010).

H. affinis reaches first maturity at about 18.0 cm FL or at around 5 months old (FAO, 2010). Most individuals however are sexually mature by 20.3 cm FL or after 7 months of age (Storey, 1983; Khokiatiwong *et al.*, 2000). The spawning season extends from November to July in which mature fish may spawn several times (Storey 1983). Bimodal spawning activity has been noted to occur with the first (minor) peak occurring during the months of November to January while a second (major) one occurs during April to May (Khokiattiwong *et al.* 2000, FAO 2010). Mature females tend to spawn in batches of around 7,000 relatively large eggs which are non-buoyant and highly adhesive (Storey 1983, Khokiattiwong *et al*. 2000). Adults will readily spawn on floating material (flotsam), the availability of which is believed to be an important limiting factor of the population size of the species in the eastern Caribbean and is also an area identified for further research (Hunte *et al*. 2007). The flyingfish becomes available to commercial fishing gear around mid-November to mid-July throughout the eastern Caribbean (Oxenford, 1994).

H. affinis feed at a relatively low trophic level (estimated at 3.79 s.e 0.56 (FishBase, 2011)) targeting mainly larval fish (nekton) and larger zooplankton such as copepods and pteropods (Lewis *et al*. 1962; FAO 2010). Flyingfish are important prey species for larger pelagics such as; billfishes, tunas, wahoo and dolphinfishes which feed on both juvenile and adult flyingfish (Hunte *et al*., 2007).

1.8.1.2 Flyingfish Distribution, Migration and Stock Structure

H. affinis can be found throughout the epipelagic zone of the western tropical Atlantic region, with concentrations of abundance in the Caribbean Sea (eastern Caribbean in particular), Gulf of Mexico and off the northeast coast of Brazil (Gomes *et al*., 1999). *H. affinis* supports important fisheries in the Lesser Antilles, Curaçao and northeast Brazil (Gomes *et al*,. 1999). The species is most often found aggregated in patchily distributed schools of varying number of individuals (Oxenford *et al*., 1995) and tends to display considerable, often quite rapid, migration and movement patterns in all directions across the eastern Caribbean (Oxenford, 1994, Hunte *et al*., 2007).Gomes et al., (1999) using mtDNA markers examined the genetic variation among spawning populations of the west central Atlantic (Barbados, Dominica and Tobago, Curaçao, Caiçara in northeast Brazil) found that there were at least three sub-regional unit stocks of *H. affinis* located in the eastern Caribbean, southern Netherland Antilles and off northeast Brazil. Khokiattiwong *et al*. (2000) examining population size structure and abundance found that there appeared to be two (2) cohorts of *H. affinis* occurring simultaneously off the coast of Barbados in May and June, one immature (mean size 19.8 cm FL) and mature (mean size 21.7 cm FL), having separate spawning seasons. This confirmed earlier suggestions by Lewis et al. (1962) and Storey (1983).

1.8.1.3 The fishery

The pelagic fishery is mainly seasonal; as it runs from November of one year to around July of the following year. Important commercial fisheries for: large oceanic, highly migratory species (e.g. yellowfin tuna, skipjack tuna, swordfish, billfish); more regional large pelagics (e.g. wahoo, dolphinfish, blackfin tuna and mackerel species); and small pelagics (e.g. flyingfish) all occur within the eastern Caribbean (FAO, 2004). The movement and migration of these stocks are transboundary; however the large regional pelagics are mostly confined to the WECAFC area, while the large oceanic pelagics go beyond this range (FAO, 2004). These fisheries can be described as multi-species and multi-gear in nature since gillnets, trolled or stationary hook and line gears or both are used to fish both small and large pelagics during the same trip. The flyingfish and dolphinfish are two species which are usually targeted together on the same fishing trip with different gear. In Barbados, these two fisheries are well developed and inextricably linked, however the majority of fishers in the other islands focus their efforts on capturing the larger pelagics.

The flyingfish has been recognized as the single most important small pelagic species in the southern Lesser Antilles; and the seven countries which fish this resource are: Barbados; Dominica; Grenada; Martinique; St. Lucia; St. Vincent and the Grenadines; and Trinidad and Tobago. It is a small fishery, with the maximum total recorded landings being 4700 t (FAO, 2010). There are approximately 1700 boats involved, and fishing operations range from small to large scale, with landings occurring at both rural and commercial facilities.

The largest flyingfish fishery is in Barbados, where approximately 62% of the reported regional catch is landed (FAO, 2010). In Barbados, flyingfish accounts for the highest value added benefits out of all fish species landed, since the estimated ex-vessel value of flyingfish is $1.79 million US while the preliminary total value calculated by adding the value of the flyingfish products consumed is $15.12 million US per year (Mahon *et al*., 2007). This represents almost a nine fold increase in the value of the flyingfish product. In Barbados, the majority of the catch is sold for human consumption; it is also used as bait. Important fisheries also exist in Tobago, Martinique and St. Lucia for human consumption; however these islands do not gain as much value-added benefits as Barbados (Ferreira, 2002). In Grenada, the flyingfish fishery is considered as a bait fishery, while fishers in St. Vincent and the Grenadines do not target the species. Fishers in Dominica target flyingfish both as food and bait (FAO, 2002a; FAO, 2010).

1.8.1.4 Fishing equipment and methods

The fishing fleets are made up of motorized vessels ranging from small open boats and fiberglass pirogues, to larger decked vessels including longliners. The small open boats are referred to as day boats and usually spend approximately 6-8 hours at sea while the larger decked boats are called ice-boats because they carry large supplies of ice and can spend between 4 to 7 days at sea. The longliners may stay at sea for more than two weeks and usually target flyingfish for use as bait or on shorter trips as a means of "quick cash" (Walcott, 2008).

The main method of fishing for flyingfish is drifting and is similar in all the different countries of the Caribbean. The fisher searches the area for the presence of flotsam (floating objects), or flock of birds, which is a good indicator of the presence of flyingfish. If flyingfish are spotted around the flotsam, the fisher immediately turns off the boat's engine and allows the vessel to passively drift with the surface currents and wind. As the boat drifts the gill net is released into the sea. If fish are not spotted in the immediate area, the fisherman deploys temporary fish attracting devices (FADs). These FADs are usually a bundle of sugar cane or coconut fronds or banana leaves attached to the boat by a length of rope. Most often a number of FADs (max of 6) are tied to the same line at roughly 100 m intervals. The fisher may also hang a basket containing pieces of fish and offal (called "chum") over the side of the boat. Once flyingfish are spotted in the area, the fisher deploys a drifting gill net and pulls the FADs closer to the boat, positioning one behind the net. This action draws the flyingfish into the vicinity of the net and facilitates their capture. Many times flyingfish are found in clusters as they spawn and can be caught using a dip net. Baited lines to capture any large pelagics in the area are usually deployed during these operations (Potts, 1987).

The vast majority of flyingfish are captured with monofilament nylon surface gillnets typically varying from 10m to 15m in length 2m to 4 m in depth. Dayboats carry 2 to 4 gillnets while iceboats may carry up to 12 nets. The modern fleet uses mesh sizes ranging from 4.3 to 4.7 cm (roughly 1⅝" to 1⅞") stretched mesh. Nets made of the smaller mesh are used at the beginning of the season when the fish are generally smaller and are replaced by the nets of the larger mesh later in the season when the fish are generally larger. Launches may have as many as three nets in the water at the same time while iceboats may have up to four. The nets are attached at intervals along the side of the vessel so that they hang vertically in the water. Each net is hauled in and cleared of flyingfish and spawn and then immediately redeployed. The soak time of the nets depends on the abundance of the fish in the area and may vary from under an hour to several hours. The length of time actually spent fishing largely depends on the time taken to gather a reasonably sized catch. For dayboats the maximum time allowed will be governed by the time that would be needed for the vessel to return to port. The mean maximum distances from shore for the main classes of vessels involved in the flyingfish fishery are approximately as follows:

- Dayboats – 8 to 46 km
- Iceboats – as far as 300km

1.8.2 Fisheries Management and Stock Abundance

Large fluctuations of fish stocks and long term changes in human harvest of marine resources are well known from long before modern exploitation started and harvesting technology became efficient enough to make significant stock reductions (Hjort, 1914; Jakobsson *et al*., 1995). Historical long term changes in stock abundance have been related to climatic changes as pointed out by Øiestad (1994), and fish stocks seem to fluctuate over time in relation to warm and cold periods in ocean waters. Andersen and Sutinen (1984) and Ishimura *et al*. (2005) acknowledged large fluctuations in stock levels and yields on a year to year basis due to stochastic recruitment processes, and Hanneson (1993) considered the choice of optimum fishing capacity of fish stocks that vary at random. Conklin and Kolber (1994) reported that stock assessment surveys consistently reveal fluctuating stock levels regardless of whether or not they are subject to exploitation. Steinshamn (1998) applied a dynamic Schaefer-Gordon model using a sine function, with alternative cycles of 4, 8 and 12 years, for the exogeneous disturbance affecting fish stock reproduction over time. A decade ago, Klyashtorin (2001) found that populations of the most commercially important Atlantic and Pacific fish species - Atlantic and Pacific herring, Atlantic cod, European, South African, Peruvian, Japanese and Californian sardine, South African and Peruvian anchovy, Pacific salmon, Alaska pollock, Chilean jack mackerel and some others - undergo long-term simultaneous oscillations.

1.8.3 Bioeconomic Stock Assessment

1.8.3.1 Objectives

The main purpose of this section is to explore the bioeconomic dynamic impacts of managing the multi-fleet and multispecies flyingfish fishery, and to undertake risk analysis of alternative fishery management decisions. Some of the management questions considered in the analysis of this stock fluctuating fishery involve the following:

1. Can this stock fluctuating fishery be managed sustainably with an open access strategy?
2. Which is the bioeconomic optimum fishing mortality and corresponding vector of catch quotas for managing a stock fluctuating fishery?
3. Which are the risks of falling below limit reference points associate to alternative fishery management strategies?

1.8.3.2 <u>Methods / Model / Data</u>

For the identified management questions, and corresponding performance variables (i.e. biomass (B_t), catch (C_t) and profits (π_t), a dynamic bioeconomic model was built with and without fluctuating carrying capacity. Bioeconomic parameters were calculated from data provided by participant countries and previous published fishery assessments. With constant carrying capacity, the flyingfish fishery model did not represent the dynamics of observed catch. Then, as suggested by Klyashtorin (2001), optimal control theory was applied to calculate: (i) the cycle and amplitude parameters of this stock fluctuating fishery that best fitted the trajectory of observed catch data, and (ii) the optimum fishing mortality (F_{opt}).

1.8.3.2.1 Time varying carrying capacity

The aggregate dynamic Schaefer-Gordon model was modified to incorporate long term fluctuating patterns in the carrying capacity of the ecosystem sustaining the four-wing flyingfish fishery. To do this, we relaxed the constant carrying capacity assumption and made it a function of time using a sine function representing the long term natural fluctuation in stock biomass. As a result, the biomass growth function is now expressed as:

$$\frac{dB}{dt} = r \cdot X_t \cdot \left(1 - \frac{B_t}{\overline{K} - \sigma_K \cdot \sin\left(2\pi \cdot \frac{t}{cycle} \right)} \right) - B_t(1 - e^{(-qf_t)}) \qquad (1)$$

Where $\overline{K}$ is the average carrying capacity, σ_k is the amplitude of the carrying capacity, and *cycle* the fluctuation period.

To calculate biomass over time, we solved numerically equation (1) using Euler numerical integration with DT=1, as follows:

$$B_{t+1} = B_t + rB_t \left(1 - \frac{B_t}{\overline{K} - \sigma_K \cdot \sin\left(2\pi \cdot \frac{t}{cycle} \right)} \right) - B_t(1 - e^{(-qf_t)}) \qquad (2)$$

Model equations used to represent the bioeconomic dynamics of the flyingfish fishery are summarized in Table 2.

Table 2. Dynamic equations used in the bioeconomic model for the flyingfish fishery.

Equation	**Description**	**Unit of measurement**
$f_{m,t} = d_m \cdot \vartheta_m \cdot V_{m,t}$	Fishing effort by fleet type m	Fishing days/year
$V_{m,t+1} = V_{m,t} + \varphi \cdot \pi_{m,t}$ Where φ > 0	Fleet dynamics: vessels of fleet m	Vessels
$\pi_{m,t} = TR_{m,t} - TC_{m,t}$	Profits of fleet m	USD/year
$TR_{m,t} = p_{ff} Y_{m,t} + p_{df} \cdot \overline{Y}_{\alpha_m} + p_{inc}$	Total revenues of fleet m	USD/year
$Y_{m,t} = B_t(1 - e^{(-q_m \cdot f_{m,t})})$	Catch of flyingfish by fleet m	Ton/year
$TC_{m,t} = c_m \cdot f_{m,t} + cs \cdot TR_{m,t}$	Total annual cost of fleet m	USD/year
$NPV_m = \sum_{t=0}^{T} \frac{\pi_{m,t}}{(1+\delta)^t}$	Net present value of fleet m	USD
$NPV = \sum_{m} NPV_m$	Net present value of the fishery	USD

1.8.3.3 Model Parameters

Initial carrying capacity was estimated using the maximum standardized catch per unit of effort divided by the daily catchability coefficient ($CPUE_{max}/q$). Both of these values are reported in FAO (2010). The intrinsic growth for the flyingfish growth function used in the study was $r = 0.3$.

For this fluctuating stock fishery, a cycle of 40 years and amplitude of 7700 ton was calculated through optimal control theory for parameter estimation. As knowledge progresses over time, flyingfish fishery analysts should update the parameter set concerning environmentally driven changes in carrying capacity over time. The bioeconomic parameter set used to feed the equations presented in Table 2 are included in Table 3.

Table 3. Parameter set used in modeling the fluctuating long term pattern of the four-wing flyingfish fishery.

Symbol	Description	Value	Unit	Source
d_1	Fishing days per trip, dayboat	1	days/trip	Data base - CFRM
d_2	Fishing days per trip, iceboat	7	days/trip	Data base - CFRM
c_1	Unit cost of effort , dayboat	109	USD/day	Ferreira (2002)
c_2	Unit cost of effort, iceboat	178	USD/day	Ferreira (2002)
cs	Catch share to pay for crew and captain	0.5	ratio	Ferreira (2002)
p_{ff}	Price of flyingfish	1220	USD/ton	Mohammed et al. (2008b)
p_{df}	Price of dolphinfish	5420	USD/ton	Mohammed et al. (2008b)
q_1	Catchability flyingfish dayboat	0.0000034	1/day	FAO (2010)
q_2	Catchability flyingfish iceboat	0.0000034	1/day	FAO (2010)
υ_1	Fishing trips dayboat	84	trips/year	Data base - CFRM
υ_2	Fishing trips iceboat	16	trips/year	Data base - CFRM
$\varphi 1$	Exit - Entry dayboat parameter	0.00001	vessels/USD	This study
$\varphi 2$	Exit - Entry Iceboat parameter	0.000018	vessels/USD	This study
$Y\alpha_1$	Weighted average catch of dolphinfish – dayboats	0.0078	kg/day	This study
$Y\alpha_2$	Weighted average catch of dolphinfish - iceboats	0.039	kg/day	This study
$Y_{\beta 1}$	Incidental harvest of other pelagic species - dayboats	0.007	kg/day	Data base - Parker, C.
$Y_{\beta 1}$	Incidental harvest of other pelagic species - iceboats	0.027	ton/day	Data base - Parker, C.
p_3	Weighted average price of incidental species	4090	US$/ton	Mohammed et al. (2008b)
δ	Annual rate of discount	0.05	1/year	This study

In the absence of equilibrium conditions which would allow for analytical solutions, a simple approach for determining a heuristic optimum control of the fishery is presented in Figure 3.

In a fishery with fluctuating carrying capacity, we would have to determine biomass and catch target and limit reference points (TRP and LRP, respectively) over time because there is no equilibrium biomass or sustainable yield. In the case of biomass, we can specify target biomass over time ($B_{t,TRP}$) proportional to the time varying carrying capacity as follows:

$$B_{t,TRP} = \tau K_t \qquad (3)$$

Where τ is a parameter value that would reflect biomass either at 0.65 of initial or any other which would tend to approximate biomass at maximum profits (e.g. maximum economic yield). On the other hand, we can also specify a biomass limit reference point over time as:

$$B_{t,LRP} = \lambda K_t \qquad (4)$$

Where λ is the proportion of biomass below which the resilience from temporary stock collapse could be compromised. For species biomass, specification of this value would depend on species longevity and vulnerability.

Management of a fluctuating stock fishery, like the one just described, can use either input or output controls, which should be updated on a yearly basis to provide proper follow up to stock fluctuations resulting from environmental factors. In Figure 3 we have the dynamic model for the fluctuating fishery receiving the input of a dynamic time varying carrying capacity (see denominator of equation (1)) determining a pattern of periodic stock fluctuations. For alternative rates of discount reflecting different prices of time, fishing mortality is optimized to yield maximum net present values. This F_{opt} is then multiplied by time varying stock biomass to determine the corresponding optimum TAC over time.

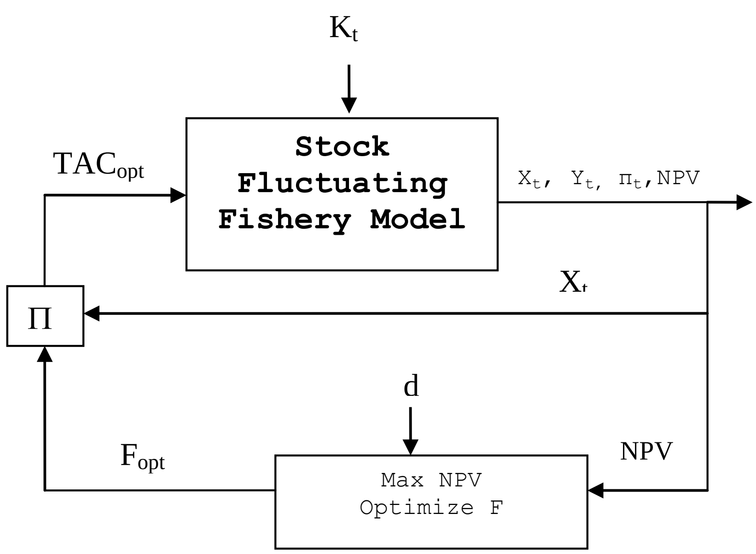


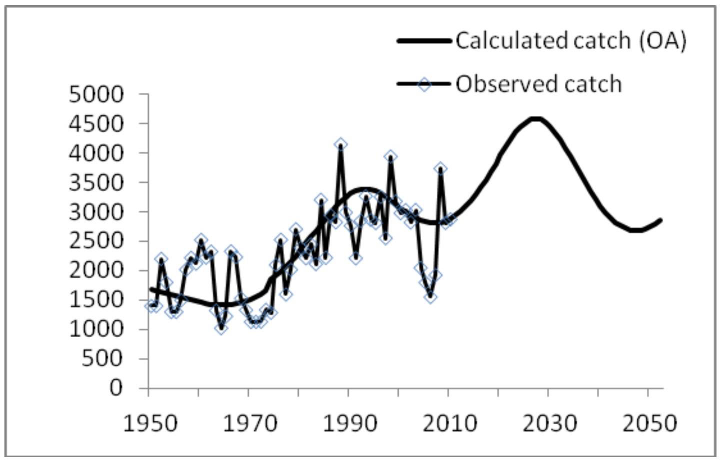
Figure 3. Optimum fishing mortality and corresponding dynamic TAC in a stock fluctuating fishery (Anderson and Seijo, 2010).

Acknowledging the uncertainty in parameters estimated and inherent fishery stochasticity, a Monte Carlo analysis was undertaken to estimate the probability of exceeding biologic (B_t/K_t) and economic LRP's (NPV) (Seijo and Caddy, 2000).

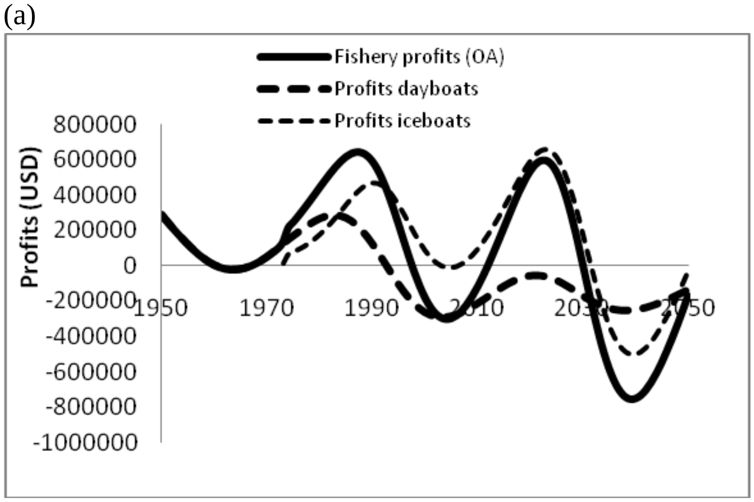
1.8.4 Results and discussion

1.8.4.1 Open access trajectories

In Figure 4 we can observe the trajectories of catch and profits over time under the current unregulated open access regime prevailing in the flyingfish fishery of the EC. Because of exogenous fluctuation of carrying capacity, there are no possibilities for reaching bioeconomic equilibrium in the fishery. Therefore, catch and profits will fluctuate in response to oscillations of resource abundance through time.



(a)



(b)

Figure 4. Catch and profits of the four-wing flyingfish fishery under open access.

The dynamics of this multispecies and multi-fleet fishery reflects adequately the trajectory of catches for the period 1950 - 2010 (See Figure4a). A Kolgomorov-Smirnof non-parametric test was used to validate the model by comparing the observed and simulated catch distributions over time.

Profits trajectory for both fleets shown in Figure 4, explain the fishery trends of the Barbados and Tobago fleet composition moving towards replacing dayboats by iceboats.

In the long-run, the current open access regime will likely result, as expected, below biomass levels which could be achieved if the fishery operates with a calculated optimum bioeconomic fishing mortality F_{opt} = 0.11, which is close to the current level of fishing mortality in the EC region.

Under open access, harvest rates in the neighborhood of 5000 ton/year could result in temporary collapse of this pelagic fishery. This situation was calculated to occur at values of F > 0.16.

The multi-species nature of this fishery involves additions to the flows of revenues to the fishery over time coming from the harvest of valuable large pelagic species like dolphinfish, tunas, and wahoo, among others. Therefore, under open access, fishermen will only partially react by reducing their effort when encountering lower biomass levels of flyingfish because the other species harvested will tend, within the relevant range, to contribute to cover the variable costs of the fishing trip. Also, it was pointed out in the discussions of the working group that price of flyingfish is very sensitive to seasonal supply of flyingfish, tending to reach substantial increases in price with low catch rates. This effect was not explored in the quantitative analysis reported here, but it is hypothesized that it will tend to accentuate the need for managing the fishery with the input and output control measures mentioned above.

1.8.4.2 Risk analysis of fishery management strategies

Monte Carlo analysis indicates (See Table 4) that with the current unregulated open access regime there is a risk of (14%) of falling below the 0.5 ratio of B_t/K_t, predetermined as the LRP by the working group that attended the FAO meeting that took place in Tobago in 2008 (FAO, 2010). In Table 4 two fishery management strategies are considered: (1) maintaining the current unregulated open access regime; and (2) establishing license limits at current level of effort of fleets harvesting the resource in the EC region.

Table 4. Probabilities of achieving target reference points (TRP´s) in biologic and economic performance indicators, and associated risks of falling below of corresponding limit reference points (LRP´s).

	B_t / K_t		Fishery Net Present Value (NPV)	
Management Strategy	TRP ≥ 0.65	LRP ≤ 0.5	TRP = (NPV ≥ 0)	LRP = (NPV ≤ 0)
Open access regime	8%	14%	19%	80%
License limiting to current level of effort	74%	0%	71%	27%

In Table 4, we can observe that with the current open access regime the probabilities of reaching biologic (Bt/Kt ≥ 0.65) and economic (NPV > 0) are very low: 8% and 19% respectively. Concerning limit reference points for the bioeconomic indicators, the risks of falling below them are calculated as 14% and 80% respectively. As pointed out in Table 1 of this report, limited licensing was considered by participants in the FAO working group on the flyingfish fishery as "probably the most appropriate tool at this time". Therefore, this was the management strategy considered in this analysis.

In Table 1 and Figures 5 and 6, we can see that limiting licensing to current levels of effort would increase the probability of achieving biologic and economic TRP's by 74% and 71% respectively. With this management strategy there is no risk of falling below the biologic TRP. Concerning the economic indicator the risk of falling below the LRP is reduced to 27%.

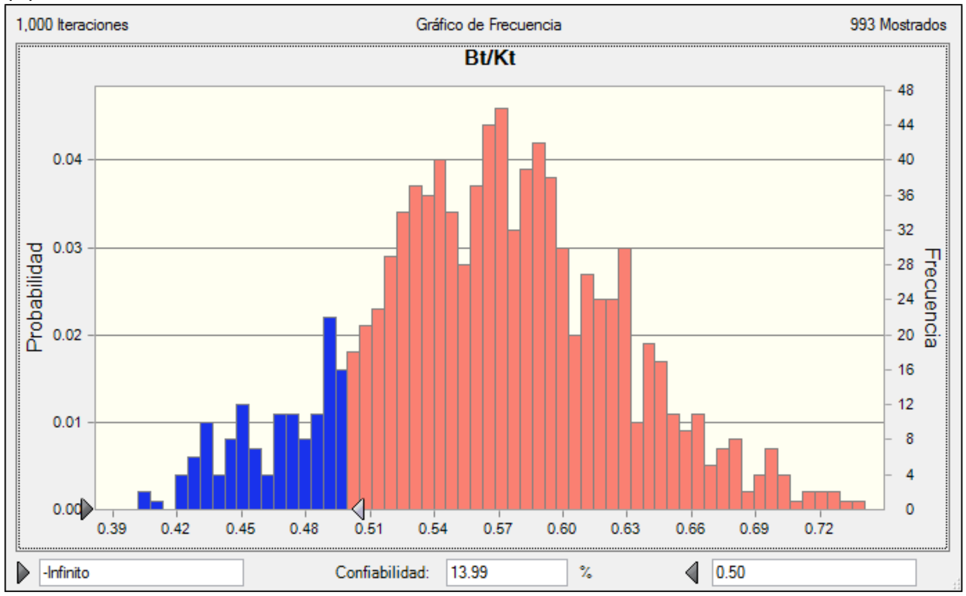
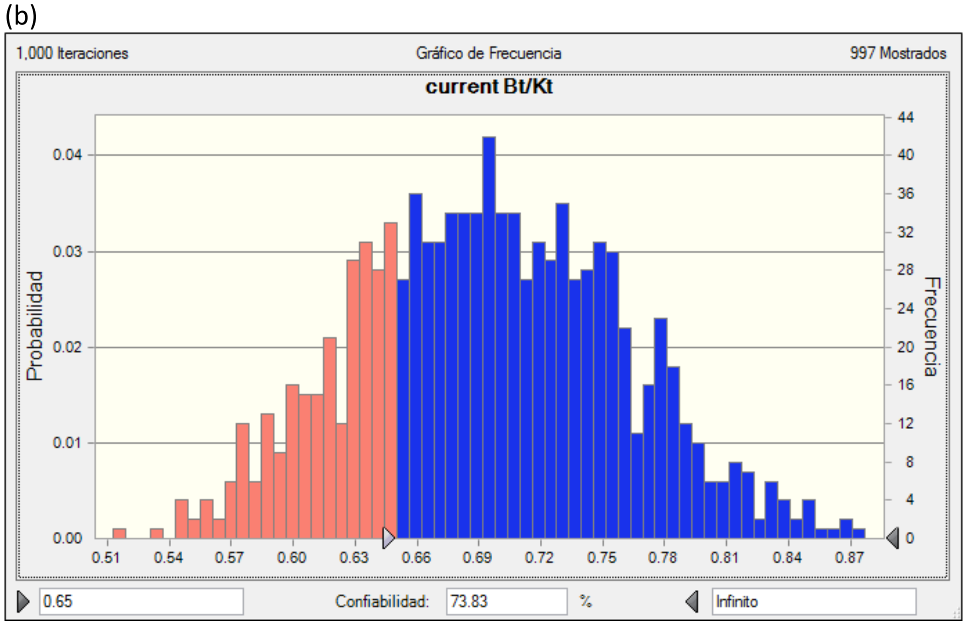
<table>
<tr><th>Management strategy</th><th>Biologic indicator: B_t / K_t</th></tr>
<tr><td>Unregulated open access regime</td><td>(a)

</td></tr>
<tr><td>License limiting to current level of effort</td><td>(b)

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Figure 5. (a) Risks of falling below biologic limit reference point of B_t/K_t = 0.5 with current unregulated open access, and (b) probability of achieving target reference point of Bt/Kt ≥ 0.65 with a license limiting management strategy.

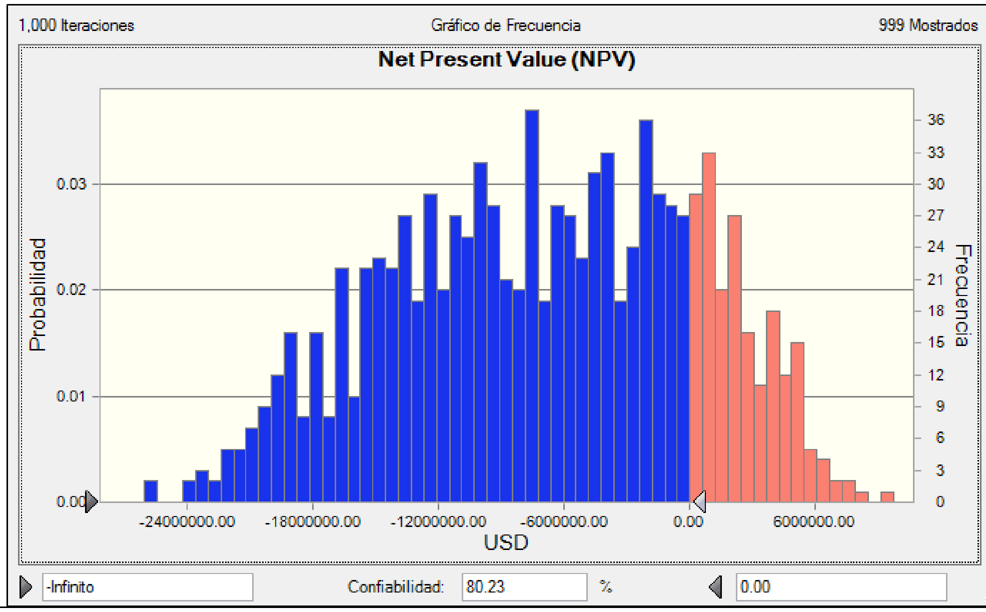
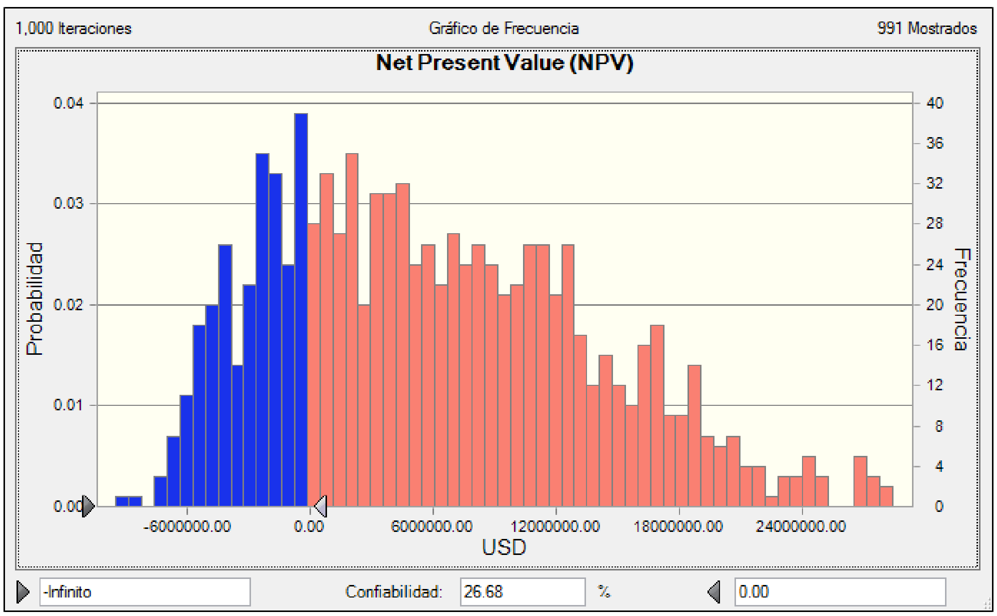
<table>
<tr><th>Management Strategy</th><th>Net Present Value of the Fishery (NPV)</th></tr>
<tr><td>Unregulated open access regime</td><td>
</td></tr>
<tr><td>License limiting to current level of effort</td><td>
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Figure 6. Risk of falling below economic limit reference point: NPV < 0 with (a) current unregulated open access regime, (b) with license limiting management strategy.

1.8.5 Conclusion and Recommendations

The main conclusions of this preliminary bioeconomic analysis of the four-wing flyingfish fishery are the following:

(i) Because of exogenous fluctuations of carrying capacity, there are no possibilities for reaching equilibrium (including bioeconomic equilibrium) in the fourwing flyingfish fishery of the Eastern Caribbean.

(ii) Non-equilibrium conditions and stochasticity precludes the derivation of analytical solutions for the differential equations describing resource and fishers dynamics.

(iii) Calculation of values of state variables for resource biomass and fleet specific effort dynamics should be undertaken using numerical integration methods (e.g. Euler numerical integration)

(iv) Effort, catch and profits will tend to fluctuate in response to oscillations of resource abundance through time, but not linearly because additional contributions of harvest of other pelagic species contribute to pay for the variable costs of daily fishing effort.

(v) For stock fluctuating fisheries, target and limit reference points should not be scalars or discrete values of biologic and economic indicators. To be meaningful, they should become time varying hypothesis vectors of TRP's and LRP's with the corresponding vector of TAC´s.

(vi) The optimum fishing mortality for the stock fluctuating fishery was $F_{opt} = 0.11$.

(vii) Under current open access regime long-run risks are high for both, biologic and economic indicators.

(viii) Model dynamic results of the Monte Carlo analysis indicate that license limiting to current levels of effort drive above mentioned risks to low levels and increase to more than 70% the probabilities of achieving bioeconomic target reference points for this fishery of the Eastern Caribbean region.

Future bioeconomic research for this important fishery of the CLME, should perhaps consider the following questions:

1. Are long-term stock fluctuations associated to changes in abundance of predators (i.e. dolphinfish, and other large pelagic species) and competitors targeted by other fleets? If so, is there a dynamic bioeconomic optimum level of effort and fishing capacity of the eco-technological interdependent fleets?
2. Is the cycle and/or amplitude of long-term fluctuating stocks changing with climate change? If so, what should the adequate vessel capacity be?

Finally, long-term stock fluctuating fisheries and possible climate change effects upon them, could suggest the following management considerations:

1. Strengthening, through education, fishing community resilience and adaptability to fluctuating stocks and changes in resource accessibility;
2. Fostering vessel malleability and versatility to facilitate shifting of target species as required by stock fluctuations and climate changes effects on species distribution and availability and over space and time;
3. Fishing licensing, for this fishery should be for multiple species rather than for single species. This would allow fishermen to react intelligently to relative stock abundance/availability and associated profits over time.

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1.9 Acknowledgements

Additional data used in the parameterization of the model were provided by Mr. Christopher Parker (Barbados), and Ms. Yvonne Edwin (St. Lucia).

Appendix 5: Report of the Shrimp and Groundfish Resource Working Group (SGWG)

Chairperson: Lara Ferreira, Trinidad and Tobago

Rapporteurs: Ranjitsing Soekhradj, Suriname (Shrimp)
Lara Ferreira, Trinidad and Tobago (Shrimp)
Anginette Murray, Jamaica (Shrimp)
Ricardo Morris, Jamaica (Shrimp)

Consultant: Paul Medley (Fisheries Consultant, UK)

A. OVERVIEW

1. Review of inter-sessional activities since last meeting, including management developments during this period.

At the 5th CRFM Scientific Meeting in 2009 the following analyses were conducted for the Atlantic seabob (*Xiphopenaeus kroyeri*) fishery in Guyana and Suriname separately as no evidence was found that the stocks were shared: a catch and effort biomass dynamics model was fitted using Bayesian framework; analysis of size composition data was conducted to determine the optimum closed season; several morphometric relationships were determined; and various other exploratory analyses were done including cross-correlations for river outflow. In the case of Trinidad and Tobago, preliminary analyses of ParFish interview data for the shrimp trawl fishery were conducted.

The Inter-sessional Work Plan documented in the Report of the Shrimp and Groundfish Resource Working Group at the 2009 Fifth Annual CRFM Scientific Meeting (the SGWG did not meet at the 2010 Sixth Annual Meeting) was reviewed and achievements noted as follows.

General

More interaction among SGWG members during the inter-sessional period was recommended via electronic mail, Skype, net meeting sites or video conferencing. There was some interaction via electronic mail among the members with respect to advancement in the ParFish assessment for Trinidad, and the development and implementation of the Harvest Control Rule (HCR) for the Suriname seabob fishery. There was a suggestion that if funding is sourced for the conduct of activities during the inter-sessional period then this would promote more communication among the members of the Group.

The Stock Assessment Parameters Profile for five species of Western Atlantic Tropical Shrimp, first developed by the Government of Trinidad and Tobago under an FAO / UNDP Project TRI/91/001 and subsequently updated, is still to be circulated among the members of the SGWG for update with new information obtained from assessments conducted at this workshop as well as any other relevant information.

Guyana and Suriname

The Fisheries Department in Suriname obtained landings by size category and effort data from the two seabob processing companies, namely Heiploeg Suriname (previously Guiana Seafoods which was bought over by Heiploeg), and Namoona. Landings data (peeled weight in pounds) by size category for 1997 to 2010 were obtained from Heiploeg Suriname with days at sea for 2001 to 2010, and landings data (live weight in kilogrammes) by size category for 1999 to 2010 were obtained from Namoona with days at sea for 2003 to 2010.

Although no bilateral meeting between Suriname and Guyana was held as recommended, some sensitivity analyses were conducted for the Suriname seabob assessment and the HCR was developed and implemented. This rule has been reviewed by the Suriname Seabob Working Group which is a management advisory group comprising the Government of Suriname, the two seabob processing companies, and the NGO World Wildlife Fund (WWF). The HCR is being reviewed monthly to monitor the status of the fishery. The relevant data are being obtained from the seabob processing companies in Suriname to facilitate the monthly monitoring of the HCR.

Trinidad and Tobago

The Parfish interview data for the shrimp trawl fishery of Trinidad and Tobago were analysed to determine the "priors" for the parameters (r, Binf, Bnow, q0) to update the Bayesian biomass dynamics model for Trinidad and Tobago and Venezuela. In order to complete this analysis the methodology was implemented in MS Excel and R. The "prior" probability of the parameters was determined based on the proximity to the fishers' estimated values. A method to use the preference interview data to estimate utility for different HCRs was developed. Seven of the 43 ParFish interviews completed were considered invalid and therefore not used in the analysis. The 1988 to 2004 time series of shrimp landings and effort data for Trinidad and Tobago were updated to 2009. A similar data set was obtained from Venezuela to update the series. Effort data however are still not available for Venezuela's artisanal shrimping fleet.

2. General review of fisheries trends throughout the region, including recent developments.

It was noted that industrial trawling in Venezuelan waters was banned by law as of 2008 which provided for a one-year transition period until 2009. It was also noted that trawling was also banned in Belize waters.

Details on the management developments in the seabob fishery in Suriname in its attempts to obtain MSC Certification were discussed and are provided as Appendix 1.

3. Fishery data preparation, analysis, and report preparation

The members of the SGWG agreed to the following work plan for the meeting.

Suriname

a) Update the 2009 assessment of Atlantic seabob (*Xiphopenaeus kroyeri*) with revised and updated annual catch and effort
b) Publish the harvest control rule (HCR) and review its performance.
c) Address any issues raised by management specifically artisanal catch

Trinidad and Tobago

a) Complete ParFish assessment for the shrimp trawl fishery of Trinidad and Tobago
b) Incorporate ParFish data into a Bayesian biomass dynamics model for Trinidad and Tobago and Venezuela
c) Develop a HCR using ParFish data
d) Review assessment and HCR and make recommendations to Trinidad and Tobago Government.

Other

a) Review catch and effort data on the marine white shrimp (*Penaeus schmitti)* fishery in the Kingston Harbour, Jamaica
b) Consider the use of hydrometric data as a recruitment/growth index using Guyana data.

Suriname

The 2009 seabob assessment was updated with the corrected landings and effort time series from the two processing companies. The current assessment used the live weight as in the previous assessments from which the harvest control rule was developed.

The current HCR for Suriname was tested against the new assessment to ensure it continues to achieve its objectives. The HCR was found to be robust to the changes in the assessment that have occurred.

The assessment and HCR were reviewed for robustness against uncertainties. Further recommendations were made to the Suriname Seabob Working Group on monitoring and procedures to ensure continued sustainability.

Catch data are not available for the artisanal fishery but the catch is estimated to be some 500 tonnes per year. Recommendations were made on designing a data collection programme to estimate this catch.

Trinidad and Tobago

Nominal CPUE indices (not standardized as this had little effect in previous assessments) were used in the logistic model. Indices were still provided separately for the main fleet types which captures the main differences among indices. Unfortunately, original raw data for the CPUE index was unavailable, but averaged data derived from the same source were used, which followed the same trends. This was combined with total annual catch obtained from Venezuela and Trinidad to update the 2006 assessment. Recent information suggests catches have substantially declined and the stock has recovered to some extent.

The stock assessment also used the Parfish interview data to carry out a decision analysis. The interviews provide a prior probability based on fisher opinions and fisher preferences among different catch and effort projections.

The fishers' preference scores with respect to various levels of effort and resulting catch were used to estimate the more preferred Harvest Control Rules. The aim would be to select those which are expected to produce the most preferred outcomes for presentation to fishers.

The base effort was taken as the median effort of the entire Trinidad and Tobago / Venezuela shrimp fleet 1991 to 2004 (30,750 days at sea in Type II equivalent effort) when the shrimp stock was at its lowest. Various lengths of closed season were considered, where the closed season reduced this effort proportionally. Note that current effort is thought to be much lower than this, but is not due to direct management intervention. In this context, a closed season would be put in place to protect the fishery against expansion back to unsustainable levels. Other controls besides a closed season were also considered, but it is not thought possible to implement other management measures at this time.

Choice of month for the closed season could be chosen based on fisher preference (Parfish interviews), or observed shrimp size in particular months or some combination of the two. It was recommended that a two month closed season be implemented and the fishers should be consulted on when the closure should take place and how these would be administered.

Other
Jamaica
Catch and effort data from 1996, 2000 – 2010 for the marine white shrimp (*Penaeus schmitti)* in the Kingston Harbour area were examined with the objective of determining the current stock status. It was

determined that based on the limited data set it would not be possible to conduct a reliable stock assessment. As a result, it was decided to conduct a review of the fishery highlighting various management issues and some of their implications. Recommendations were then put forward to address these issues.

Time did not permit the consideration of hydrometric data as a recruitment /growth index using Guyana data.

4. Inter-sessional workplan and Recommendations.

<u>Inter-sessional workplan</u>

General

The Stock Assessment Parameters Profile for five species of Western Atlantic Tropical Shrimp, first developed by the Government of Trinidad and Tobago under an FAO/UNDP Project TRI/91/001 and subsequently updated, will be circulated among the members of the SGWG for update with new information obtained from assessments conducted at this and previous workshops as well as any other relevant information.

Suriname

The artisanal catch of seabob is to be estimated as part of the requirement for MSC certification. This can be done based on information from the seabob buyers or by sampling the artisanal landings. If it can be verified that the artisanal landings are less than 5% of the total seabob catch then no further monitoring of this component of the fishery will be required in the longterm. If estimates suggest these catches are significant, a time series of estimated catches needs to be developed for inclusion in the assessment.

The catch and effort data series is to be extended as far back as possible prior to 1998 for the seabob fishery.

Trinidad and Tobago

The results of the ParFish analysis and biomass dynamics assessment for the shrimp fishery of Trinidad and Tobago and Venezuela are to be presented to the fishing communities.

A closed season for the shrimp trawl fishery of Trinidad and Tobago is to be implemented in collaboration with the fishing industry stakeholders.

Computerization of the Trinidad historical catch and effort data from the 1950s to the 1990s is to be continued.

Jamaica

The national sampling plan for the white shrimp fishery that would facilitate regular stock assessments is to be implemented.

An independent monitoring of white shrimp catch rates in various areas within the Kingston Harbour (and possibly other areas) to determine the status of the stock and explore alternative fishing areas is to be conducted.

A programme to obtain a socio-economic baseline which will complement the biological data for the fishery is to be implemented. This baseline must include, but not be limited to; the number of active fishers and vessels per year, earning per fisher/boat, basic household information, the degree of importance of the fishery (economic and nutritional), operating costs of fishing

Relevant areas of the above recommendations are to be included in a management plan for the fishery and the associated legislative regulations put in place.

<u>Recommendations</u>

General

An official membership list for the CFRM SGWG should be established to facilitate and promote interaction among the member countries on issues related to these fisheries.

Funding could be sourced for the conduct of assessment- or management-related activities during the inter-sessional period. The World Wildlife Fund (WWF) is one of the organizations identified as offering funding in the area of fishery improvement plans with a view to raising the standard of fisheries management to facilitate Marine Stewardship Council (MSC) Certification.

The use of hydrometric data as a recruitment/growth index should be considered as such factors as water levels and water flows may cause fluctuation in stock size and hence help to explain variation in CPUE and if so should be taken into consideration in the HCR. Data are available from Guyana for such exploratory analyses.

Suriname

The **measured** weights should be obtained from the seabob processing companies and not the weights to which conversion factors have already been applied for eg. Namoona measures peeled weight in pounds (so this is the measurement that should be obtained) but applies the factor 2.3 to convert to live weight and then divides by 2.2046 to convert to kilogrammes.

Peeled weight (instead of live weight) in kilogrammes should be used in the assessment in future. The morphometric and size frequency data should be examined at the next meeting as they provide some information on size and age structure, which are not addressed by the current assessment. The research should give estimates of growth rates, maximum size and mortality rates for independent comparison with the results obtained from the catch and effort data.

Issues related to bycatch should be considered. Such issues are included in the research plan developed for this fishery by the Suriname seabob management working group. This research plan forms part of the management plan.

Trinidad and Tobago

Review historical records and consult with Trinidad industrial trawl fleet operators in an attempt to verify or refine shrimp catch estimates prior to the year 2000 when sampling of this fleet was very low or non-existent.

Implement a trip reporting system for the semi-industrial and industrial trawl fleets of Trinidad and Tobago.

Implement an Observer Programme for the semi-industrial and industrial trawl fleets to verify the trip reporting system.

Structure data collection to allow individual shrimp species to be monitored.

Obtain more detailed information, including on species life history, to account for other factors affecting productivity, such as pollution, which was suggested as a contributing factor by stakeholders.
The shrimp stock distribution in Trinidad and Tobago waters should be investigated. Salinity, water temperature, depth, chlorophyll distribution, shrimp species composition, and any other data which would assist in determining the stock distribution should be collated.

Re-evaluate stock structure as the current assumed structure, effectively a single stock shared between Venezuela and Trinidad, may not be accurate enough to protect fleets from depleting the resources they have access to.

Recommendations to improve the logistic model for the Trinidad and Tobago/Venezuela shrimp fishery:

- Consider changing catchability due to any shifts from targeting shrimp to targeting bycatch.
- Include the CPUE standardization as part of the stock assessment rather that performing this outside the assessment and pulling in the results.
- Estimate the shrimp CPUE for the historical years

Jamaica

An assessment incorporating the socio-economic baseline data of the white shrimp fishery should be conducted at the ninth CRFM scientific meeting (in the next two years).

5. Review and adoption of Working Group report, including species / fisheries reports for 2011.

The Working Group Report will be finalized, reviewed and adopted by the members of the SGWG via electronic mail during the inter-sessional period.

6. Adjournment.

The meeting of the SGWG adjourned at 5.40 pm on 23 June 2011.

B. FISHERY REPORTS

1.0 The Seabob (*Xiphopenaeus kroyeri*) Fishery of Suriname

Ranjitsing Soekhradj, (Rapporteur, Suriname)
Paul Medley (Consultant, UK)

1.1.1 Management Objectives

- This fishery sustains a large number of families, and is also one of the few profitable occupations in some rural areas. Preservation of this source of income, and of the living standards of the population involved, are important objectives.
- The way fishermen themselves are managing their activities, adjusting effort in accordance with expected (net) benefits, can be seen as a way of optimising economic yield.
- Fresh and dried shrimp are traditional commodities for the local market, and also an important contributor to the domestic protein supply.
- Frozen seabob, produced by the seabob processors, is exported, and dried shrimp might have export potential (not demonstrated yet). Generation of foreign currency must therefore be taken into account in management.

1.2 Status of Stock

The assessment indicates that the stock is not overfished (B/B_{MSY} > 1.0) and overfishing is not occurring (F/F_{MSY} < 1.0; Figure 1; Table 1). This conclusion depends, among other things, upon a reasonably accurate time series of total catch. The total catch has now been verified back to 1999 and further improvements are not likely to change the current determination. Results remain broadly the same as those from the last stock assessment in 2009.

Table 1 Stock assessment results with 90% confidence intervals.

Parameter	Lower 5%	Median	Upper 95%
R	0.39	0.68	1.04
B_∞ (t)	40437	60822	109838
B 2010 (t)	0.60	0.68	0.76
MSY (t)	9293	10465	12068
Current Yield		7584	
Replacement Yield	8640	9056	9164
B/BMSY	1.19	1.37	1.51
F/FMSY	0.45	0.57	0.71

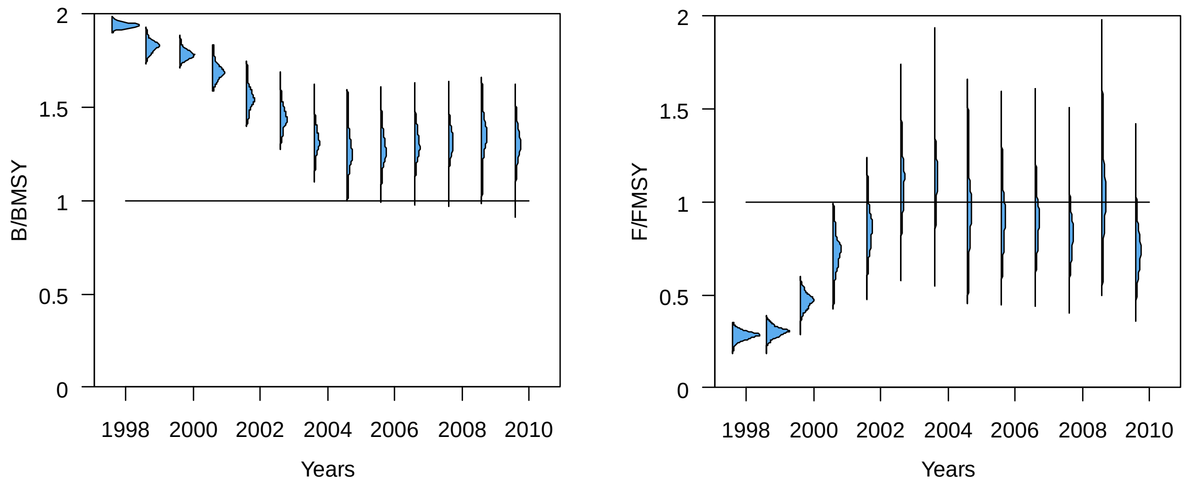

Figure 1. Probability estimates of the biomass and fishing mortality relative to the MSY value based on the Monte Carlo integration of the model posterior. The range of values is shown from 5000 random draws from the posterior probability using a Monte Carlo integration. More peaked distributions indicate greater certainty in estimates, whereas flatter distributions indicate greater uncertainty.

1.3 Management Advice

It is recommended to continue applying the current harvest control rule for several years to allow it to be evaluated. On evaluation, further scientific recommendations might be made.

New reference points and a harvest control rule have been adopted based on the maximum sustainable yield point (MSY), with the biomass limit reference point at 60% and target reference point at 120% of the MSY estimate respectively.

CPUE is used as a proxy for the biomass, with reference points based upon the previous 2009 stock assessment. Results from the current assessment suggest that these reference points are more precautionary than originally intended (Table 2). The CPUE expected at MSY is 1.38 t day^{-1}, whereas current CPUE is 1.76 t day^{-1}.

The harvest control rule uses the proxies CPUE and days-at-sea for biomass and fishing mortality, taking into account the uncertainty with which the values of interest have been estimated (Figure 2).

The most important finding with respect to the harvest control rule is to ensure the CPUE index remains valid. The greatest risk to the index is change to the fleet, including alterations to gears, vessels or operations. It is important that any and all changes are monitored and managed carefully. It should be ensured that catch and effort data can be separated by vessel, that gear and operations are recorded by vessel and if changes are to occur that these are not undertaken simultaneously across the fleet.

Table 2 Comparison between CPUE (t / day at sea) reference points for 2009 and 2011 (the most recent assessment). The trigger reference point is the expected CPUE at MSY. The 2009 values are used in the current harvest control rule, which the most recent stock assessment suggests are precautionary. The 2011 are more accurate estimates of the appropriate values, so reference point values higher than these are more precautionary.

	2009	2011
Limit	0.89	0.83
Trigger	1.48	1.38
Target	1.65	1.66

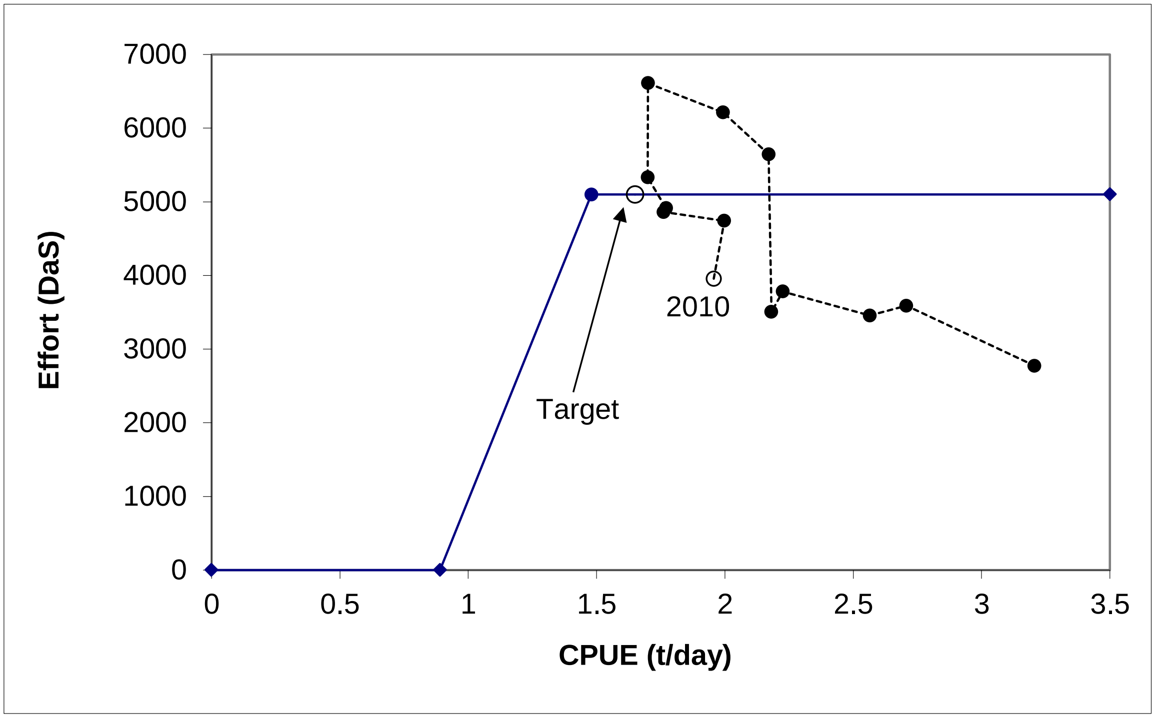

Figure 2 Harvest control rule (HCR) being applied to the fishery with historical time series of HCR CPUE calculated as a moving average and effort for the corrected data. The target CPUE is shown along with the estimated HCR CPUE in 2010 (from the 2011 assessment). This can be interpreted as the point estimates of fishing mortality are below the target level and biomass above the target level.

The harvest control rule has not been in operation long enough to allow any evaluation. However, based on the historical behavior of the fishery, it remains the best estimate for limiting the fishery to sustainable exploitation levels and therefore should be implemented while undergoing monitoring for at least three years. The CPUE projected under the harvest control rule should on average fluctuate above the target CPUE (Figure 3).

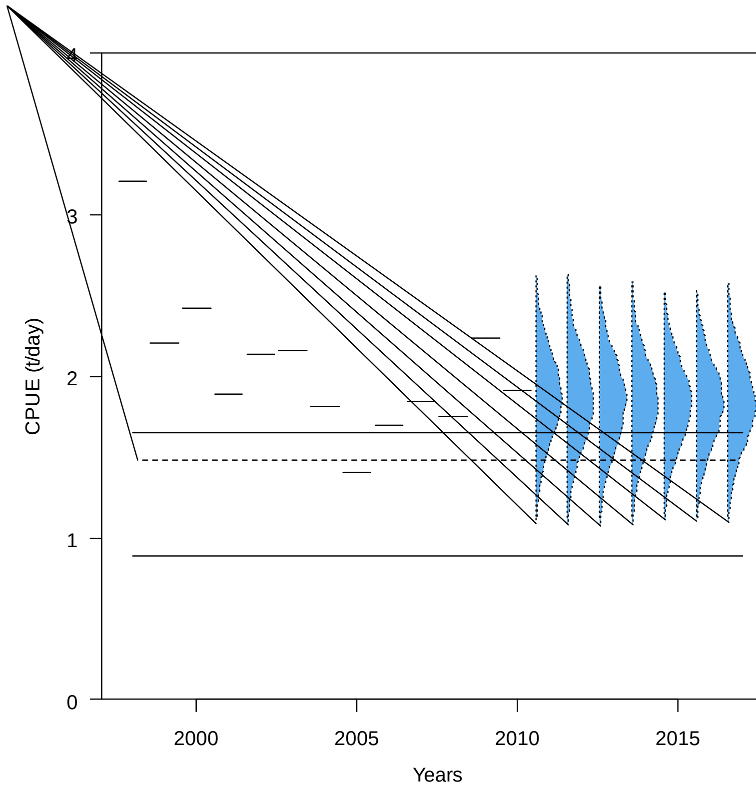

Figure 3 Observed historical CPUE (horizontal line) and projected probability distribution under the harvest control rule. The model predicts that it is highly likely that the CPUE will remain above the target level.

1.4 Statistics and Research Recommendations

1.4.1 Data Quality

Annual catch and effort data were available for the period 1998-2010 and monthly data available for 2002 - 2010 (Figure 4). Previously errors had been found in the catch and effort data. These errors have, to a large extent, been eliminated and the catch effort data have been validated back to 2001 and the total catch data validated back to 1999.

The morphometric and size frequency data were not examined at this meeting due to insufficient time. These data should be examined at the next meeting as they provide some information on size and age structure, which are not addressed by the current assessment.

Additional catch data were used which were obtained from the FAO FIGIS database. These data are not likely to be very accurate, but were of sufficient accuracy to allow catches to be estimated back to the start of the fishery. The level of precision of these data was sufficient for this analysis. Further validation of the historical data is still required and should be completed during the inter-sessional period.

As well as validating export catch estimates, the local artisanal catches for the dried seabob market need to be estimated. If estimates suggest these catches are significant, a time series of estimated catches needs to be developed for inclusion in the assessment. It is important to note that unless there have been significant changes in these catches over time, they would not lead to a change in stock status, but they will affect the estimate of absolute biomass.

1.4.2 Research

A research plan has been developed for this fishery by the Suriname seabob management working group, and this research plan forms part of the management plan. This includes new issues related to bycatch which has not been previously considered by this working group.

The primary aim for the stock assessment is to complete validation of the total catch, including estimates of the artisanal catch.

Research is continuing on growth and mortality of seabob through the collection of detailed size frequencies. A considerable data set is already available, but analysis is incomplete. The data were reviewed and some analysis completed at the 2009 meeting. The research should give estimates of growth rates, maximum size and mortality rates for independent comparison with the results obtained from the catch and effort data. It is recommended that high priority be given to the analysis of these data.

1.5 Stock Assessment Summary

Bayesian statistics and the Monte Carlo (Sample importance resample algorithm) methods were used to estimate probability distributions for Maximum Sustainable Yield (MSY)[1], Replaceable Yield[2], current biomass relative to biomass at MSY, and current fishing mortality relative to fishing mortality at MSY. The assessment used the logistic biomass dynamics model fitted to the total catch 1989-2010 and catch and effort 1998-2010.

Catch per unit effort (CPUE)[3] was used as an index of the abundance of stock. The measure of effort used was the number of days at sea, which would include steaming time. This was the only measure of effort available, but was thought to be strongly related to the amount of fishing carried out. The CPUE index has appeared to decline each year to 2005, but has also shown a recent increasing trend (Figure 4). The results indicate a reasonable fit of the model (Figure 5), but it should be noted that although the model largely explained the trends in the CPUE, these trends formed only a small part of the variation in CPUE. The number of data points (13) was limited and with only very shallow trends, the four parameters could only be weakly estimated.

The maximum sustainable yield was estimated to be between 9 000 and 12 000 t year^{-1} (Table 1). However, in absolute terms, biomass, and therefore yield is poorly estimated (Figure 6). Hence, the harvest control rule based on CPUE and effort rather than catch will be much more reliable.

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[1] **Maximum Sustainable Yield** or **MSY** is, theoretically, the largest yield/catch that can be taken from a species' stock over an indefinite period. Any yield greater than MSY is thought to be unsustainable.
[2] **Replacement Yield** is the yield/catch taken from a stock which keeps the stock at the current size.
[3] **CPUE** is the quantity caught (in number or in weight) with one standard unit of fishing effort.

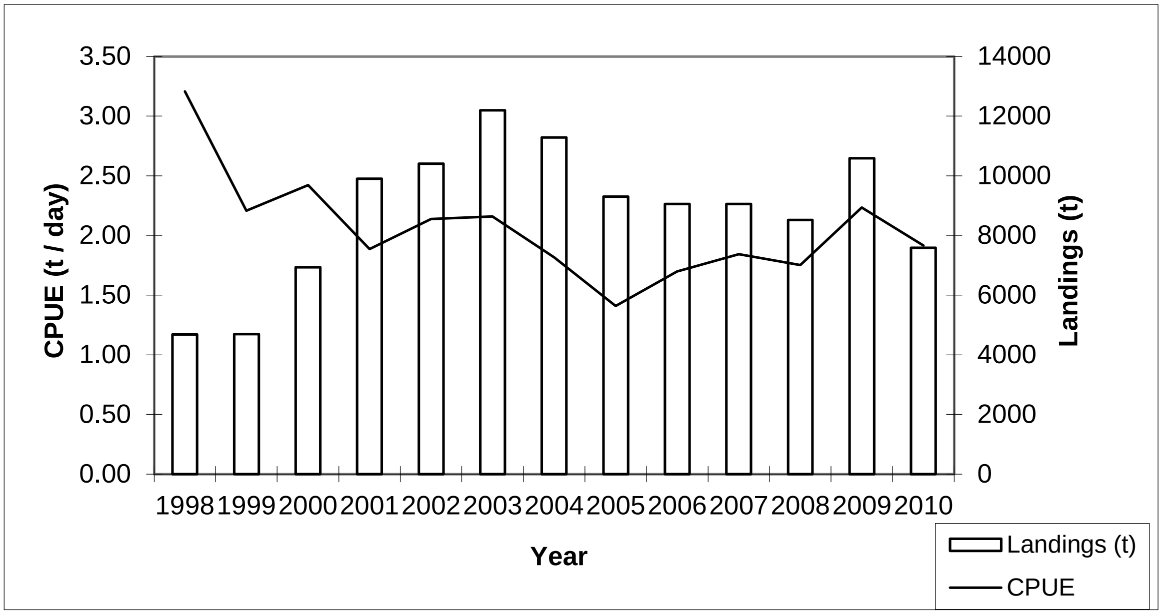

Figure 4 The CPUE abundance index shows a continuous decline since 1998 to 2006, suggesting that the stock abundance has declined over this period. However, there is some indication of more recent increase in catch rate following reduced catches after 2005.

1.6 Special Comments

In 2008 it was recommended that Suriname and Guyana have similar programs for collecting biological data. This has been successfully achieved through a standard data collection protocol implemented in the processing facilities of Guiana Seafoods (Suriname) and Noble House Seafoods (Guyana).

The Suriname seabob fishery is currently undergoing Marine Stewardship Council certification (www.msc.org).

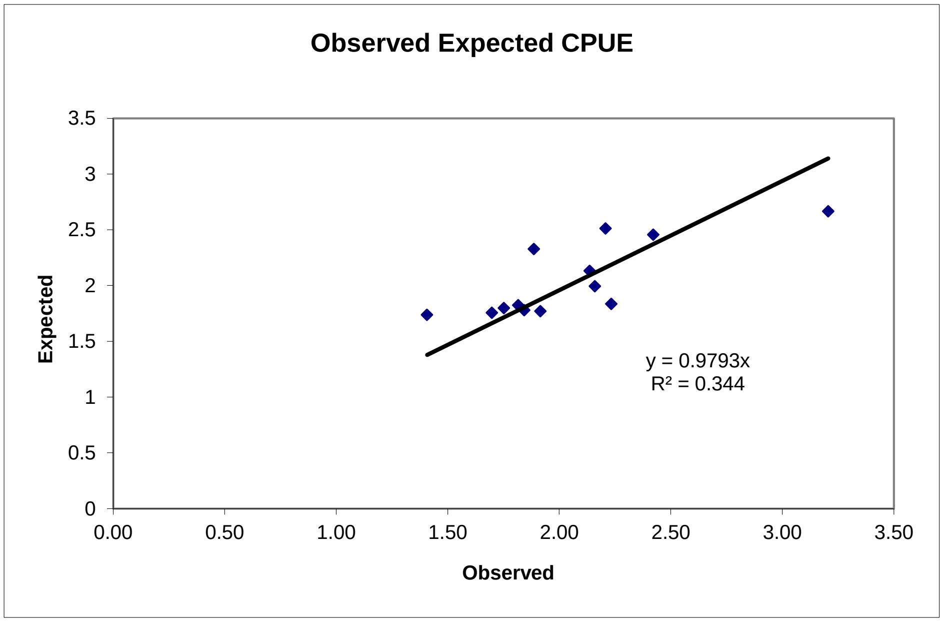

Figure 5 Observed and expected CPUE from the model fit. The residuals show no obvious pattern around the regression line going through the origin.

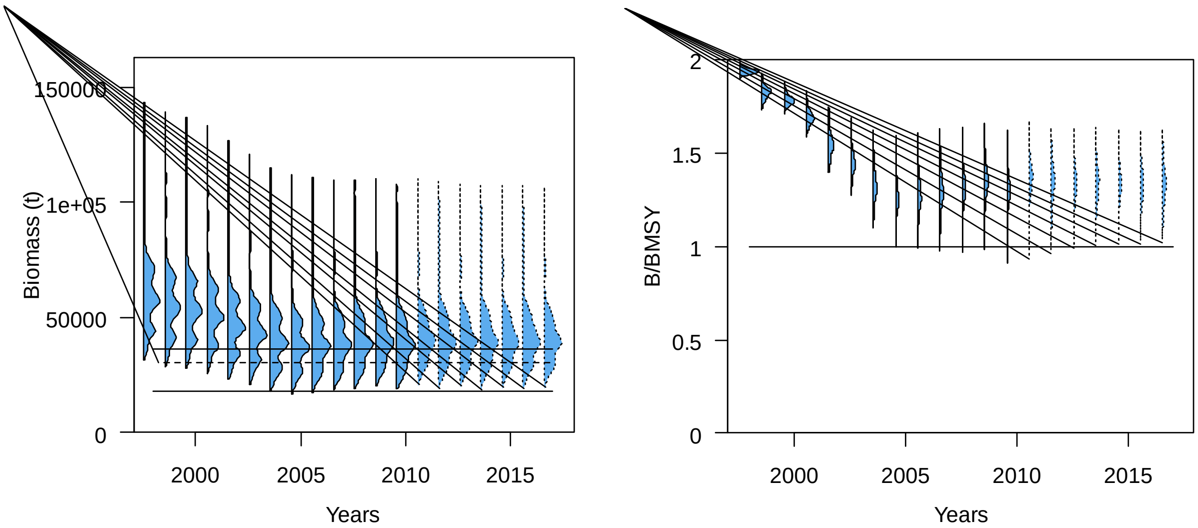

Figure 6 Absolute and relative biomass probability distributions for estimates (solid) and projections (dotted) from the fitted stock assessment model. The relevant reference points are also shown as horizontal lines with target (120% median MSY), trigger (dotted; median MSY) and limt (60% median MSY) for biomass, and MSY level for the relative biomass. Although biomass is uncertain, the relative biomass is very likely to remain above the MSY reference point.

1.7 Policy Summary

The role of the fisheries sector could be expressed as follows:

- Provides employment at the primary and secondary levels. The fishery also creates more alternative job opportunities and reasonable incomes. Diversity of the sector is also important.
- Creates a balance of payment through export of fish and shrimp products

- Contributes to the GDP of the country
- Contributes to the national budget through fees and income tax.

The main policy is to manage the fish and shrimp resources in a sustainable manner to generate revenues on a long term basis and to provide further development opportunities.

1.8 Scientific Assessments

1.8.1 Description of the Fishery

The seabob industrial trawl fishery started in 1996 with one company, which owned 10 boats. In 1997, this company increased the number of vessels to 15, and a second company joined the fishery, with 3 vessels. At present, the seabob fleet comprises 24 vessels owned by two companies, namely Guiana Seafoods N.V (GSF) and Namoona with 15 vessels and 9 vessels, respectively. The vessels licensed to fish for seabob are 18-36m in length. Seabob is exploited in the EEZ at depths of 11-24 m. The catch is processed by two processing plants.

There is also an artisanal fishery for seabob with about 500 vessels; this fishery uses Chinese seines, drying the seabob for local consumption. Catches prior to 1996 are attributed to this fishery.

1.8.2 Overall Assessment Objectives

The main objective of this assessment was to update the status of the stock and reference points using the new corrected data and test the harvest control rule currently being used for Suriname seabob fisheries.

1.8.3 Data Used

Name	Description
Total seabob landings	Reported monthly seabob landings based on processor reports 1989 – 2010
Catch and effort data	Reported seabob landings and days at sea per trip based on processor reports 1998 – 2010

The data were reviewed and checked at the scientific meeting in 2009. While data were considered likely to have errors, based on raw data sources, government data were found to have the same trends and patterns, and therefore they were used for the stock assessment at that time even though correction was recommended. Since then, data have been corrected (Table 3).

Table 3 Original and corrected catch effort data used in the 2009 and 2011 stock assessments respectively. Shaded values have not been fully corrected and confirmed yet, although some checks and improvements have been made. Landed catches in bold are highlighted where significant changes in values have occurred. Errors have occurred for a variety of reasons primarily due to inconsistent reporting of the processed state of the catch (peeled vs unpeeled) and units of weight. Some errors are still apparent (corrected landings column 6 should be less than or equal to corrected total landings column 3), and further corrections will be applied where possible. Landings are in metric tonnes, effort in vessel days-at-sea.

	Total Landings		Original		Corrected	
Year	**Original**	**Corrected**	**Landings**	**Effort**	**Landings**	**Effort**
1989	459	459				
1990	130	130				
1991	319	319				
1992	131	131				
1993	30	30				
1994	116	116				
1995	230	230				
1996	1674	1674				
1997	1243	1379				
1998	4681	4681	8888	2772	8888	2772
1999	7924	**4696**	7924	3588	7924	3588
2000	8369	**6932**	8369	3456	8369	3456
2001	13319	**9898**	10343	4020	7132	3781
2002	6961	**10405**	10858	4716	7489	3504
2003	7438	**12192**	12130	4764	12192	5644
2004	10696	11284	10567	5292	11284	6213
2005	9291	9303	9141	5592	9303	6610
2006	10425	9053	10340	4656	9053	5330
2007	8061	9055	8288	4116	9055	4913
2008	8224	8516	8173	5064	8516	4860
2009		10590			10590	4741
2010		7584			7584	3958

The largest change was the result of corrections to data recording and ensuring consistent measurement of data in terms of units and level of processing. It is strongly recommended that raw weight data are recorded and reported to government. In this case, this would be the shelled tail weight in kilogrammes, which is actually measured. Other statistics might then be derived in a consistent way.

1.8.4 Assessment 1: Stock Assessment Method

1.8.4.1 Objective

Update the stock assessment using the new catch and effort data (above) and test the robustness of the current harvest control rule to the new assessment.

1.8.4.2 Method / Models / Data

The method applied is the same as that developed for the assessment in 2009. A brief summary is presented here, and more detail is provided in CRFM (2009) in Section 5.4 pp123-129.

A biomass dynamics model was fitted to the data using a Bayesian framework to allow greater flexibility and a better evaluation of the assessment uncertainty. The population model requires an initial stock state

(B_0), rate of increase (r) and unexploited biomass (B_∞). These parameters each require information to improve the estimation. The catchability parameter (q) prior is assumed uniform (uninformative) on a log scale.

The same priors were used as in CRFM (2009), although the catch and effort data were updated. The priors consisted of a presumption that the stock was only lightly exploited at the start of the time series, a loose correspondence in productivity per unit area between this fishery and others reporting biomass estimates based on scientific surveys. The prior for the intrinsic rate of increase was based on estimates obtained for other stock assessments for penaeid shrimps.

The likelihood for the observations was the normal (Gaussian) probability density function (pdf) fitting between the observed and expected CPUE index. The expected CPUE index is calculated as the catchability parameter multiplied by the biomass abundance. In contrast to the previous assessment, the variance (σ) parameter was also fitted using the same Bayesian methods, increasing the number of fitted parameters to five.

A sample-importance algorithm was used to fit the model, where the approximating density could be improved during the fitting process. This is the same method as used previously, which builds an approximate pdf from repeated sampling from the target posterior function.

The method has been implemented using Visual Basic in an MS Excel spreadsheet and R through RExcel. While this implementation is numerically slow, it was considered useful in developing the method to use spreadsheets to manage the compiled data and develop the basic population, likelihood and priors as this was flexible in setting up models and provided a more transparent fitting procedure. The full code and spreadsheet are available on request (paulahmedley@yahoo.co.uk).

1.8.4.3 Results

The fitting method worked reasonably well, and the model was able to apply the importance sampling method where the importance range was relatively low (a maximum log weight of less than 1.0 and minimum greater than -8.6 corresponding to the number of random draws). This excludes very high or low importance weights. Improvements in the fit will be sought in future assessments, specifically by applying full rejection sampling. The results are a reliable representation of the posterior, but all uncertainties with respect to model and data still apply.

The marginal probabilities of various performance indicators were obtained from the posterior. These are true probabilities and can be interpreted as such. The main performance indicators were biomass relative to biomass at MSY, the replacement yield, the maximum sustainable yield and current fishing mortality relative to fishing mortality at MSY. The main results of the stock assessment are presented in Stock Status (Section 1.2) and Management Advice (Section 1.3). Most importantly the results suggest that it is likely that the stock is not overfished, and overfishing has not occurred in 2010.

The data set needs further revision, but this is likely to have lower impact on the results and therefore the status and management advice are not likely to change. In comparison with the previous assessment, the estimated biomass is lower, and slightly more exploited, but overall the status remains broadly the same (Table 4). Importantly, the current harvest control rule appears precautionary and should not lead to overfishing (Figure 7).

Table 4 Comparison of the median estimates between the 2009 and 2011 assessments. Note that stock status relative to MSY (B/BMSY and F/FMSY) refer to different years (2008 and 2010), although with little change in the fishery, they should be comparable.

Parameter	2009	2011
r	0.60	0.68
B_∞	110481	60822
B_{now}	0.73	0.68
MSY (t)	16651	10465
B/BMSY	1.46	1.37
F/FMSY	0.45	0.57

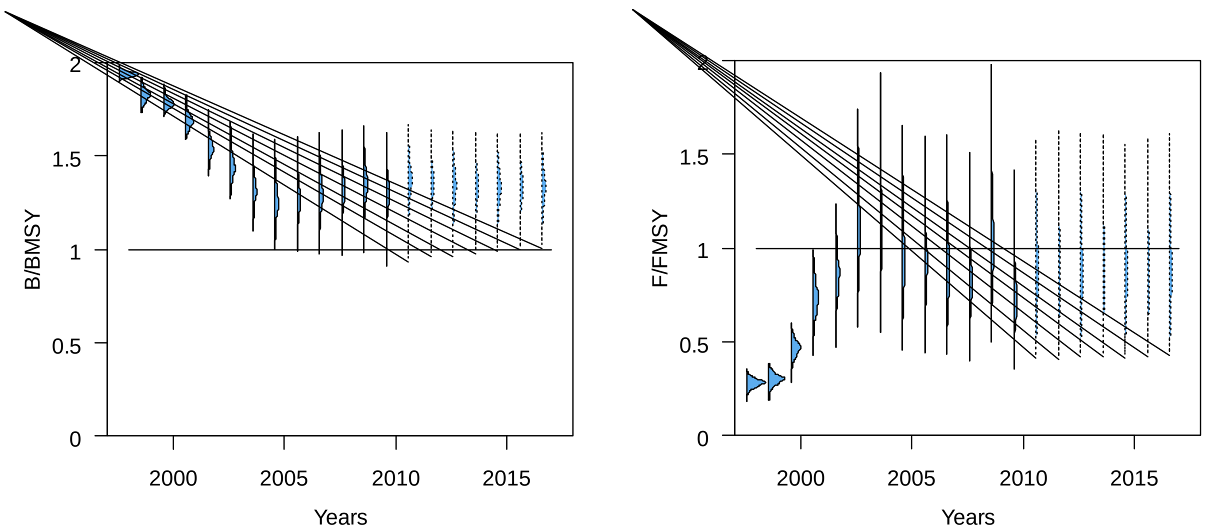

Figure 7 Past status of the fishery and projected status under the current harvest control rule.

1.8.4.4 Discussion

It appears that the current harvest control rule is robust to data errors and should continue to protect the stock as long as catchability does not change (see Section 1.8.5 on developing and testing the Harvest Control Rule). Based on this update assessment, it is recommended that no changes are required in the harvest control rule at this time.

The key assumptions of the stock assessment and source of uncertainty not represented in the probability density functions are:

1. The CPUE index is proportional to abundance.
2. The biomass dynamics model is appropriate for describing the dynamics of the species.
3. Total catches are well estimated.
4. The information included in the priors is valid.

Of these assumptions, further evaluations and corrections have occurred for 1 and 3. Nevertheless, ongoing improvements should be conducted where possible and a full evaluation of the assessment and management, and an update of the harvest control rule carried out in 2013.

1.8.5 Harvest Control Rule Testing

Paul Medley (Consultant, UK)

1.8.5.1 Summary

The harvest control rule (HCR) used for the Suriname seabob fishery was tested using Monte Carlo simulation. The rule was shown to be robust to uncertainties, but identifies those changes that could occur which will require monitoring to update the rule and ensure that it remains valid. The possible uncertainties that could create a problem are changes to the productivity of the stock (e.g. recruitment), hyper-stability in the index, sample or process error swamping information in the index and changes in catchability. The HCR is shown to be robust to all these, or they appear not to be a problem from the available evidence, except for possible changes in catchability. Significant changes in catchability will invalidate the abundance index and the HCR. Therefore potential changes to the catching efficiency, including the use of bycatch reduction devices, will need to be controlled and monitored carefully so that the HCR can be updated as necessary.

1.8.5.2 Derivation of the Harvest Control Rule

The harvest control rule was agreed among stakeholders, represented by the two fishing companies involved in the seabob fishery, the Suriname government and other members of the Fisheries Advisory Committee. The rationale and background behind their choice of harvest control rule is described below. One of the objectives was to develop a harvest control rule consistent with the Marine Stewardship Council standard (www.msc.org), because the fishery was being put forward for certification.

A stock assessment was completed in 2009 (Derrell *et al*. 2009), which forms the basis for the harvest control rule. The harvest control rule needs to be based upon the reference points from the stock assessment, which will depend upon the estimated maximum sustainable yield and the level of risk which the fishery stakeholders are willing to accept.

The criteria for choosing the harvest control rule were as follows:

1. The target level of fishing mortality must be set at MSY or below. Fishing beyond MSY could not be justified on either economic or ecological grounds and would not meet the MSC standard.
2. The HCR should be based on constant effort rather than a constant catch. This allows some automatic adjustment in the catch in response to changes in abundance without management intervention.
3. The HCR should be simple and easy to understand. This is beneficial not just to the stakeholders, who can immediately see the implications of the different controls, but also the scientists who can design and test the control rule more easily to achieve the management objectives.

For these reasons, the harvest control rule is based upon easily measurable variables: days-at-sea, representing fishing mortality, and catch per day-at-sea (D-a-S) representing abundance. Based on the stock assessment, all variables of interest including the reference points can be translated into these proxies (Table 5). CPUE also has the additional value of being directly measured with estimable characteristics of a random variable. This allows the rule to take full account of the estimable part of uncertainty (sample and process error) and be adjusted to take account of a defined acceptable risk.

Suriname Seabob Harvest Control Rule (see Figure 8)
The Total Allowable Days-at-sea (TAD) shall be set at: • 5100 days-at-sea when the current catch rate is <u>at or above</u> the trigger catch rate. • a linearly declining value when the current catch rate is <u>below</u> the trigger catch rate according to the calculation: TAD = (Current Catch Rate – Limit Catch Rate) * 8625 • zero (the fishery is closed) if the current catch rate is at or below the limit catch rate. The trigger catch rate shall be set at 1.48 tonnes per day-at-sea. The current catch rate for each year shall be calculated as the average between the previous year's current catch rate and catch rate of the current year. The catch rate is calculated as the total landings of seabob divided by the total number of days-at-sea for the fleet. The target catch rate shall be set at 1.65 tonnes per day-at-sea and the limit catch rate shall be set at 0.89 tonnes per day-at-sea.

Table 5 Summary of Reference Points for standard and proxy indicators. The MSY represents the minimum allowable target/limit biomass and the SGWG target/limit is a precautionary biomass recommended by the SGWG. The Stakeholder reference points were actually implemented in the management plan.

Reference Point	Standard Indicators		Proxy Indicators	
	Biomass (t)	Fishing Mortality[a]	Days at sea	CPUE (t/D-a-S)
MSY (Lowest B Target)	43679	0.22	5662	1.48
50% MSY (Lowest B Limit)	21840	0.36	8624	0.74
SGWG Target (120% MSY)	52415	0.18	4599	1.77
SGWG Limit (60% MSY)	26208	0.33	8049	0.89
Stakeholder Target	48697	0.19	5100	1.65
Stakeholder Limit	26267	na	na	0.89
Stakeholder Trigger	43679	na	na	1.48

[a] The mortality here is based on the exploitation rate of the biomass, not numbers, and so is only the same as a numbers-based F if all seabob would be the same size. In practice, estimates should be very similar.

In further developing the HCR, various configurations were tested using a simulation approach (see Section 1.8.5.3.2 1.8.5.3.2 Simulation *Method*). These considered the alternative reference points, the way the CPUE index was calculated, the placement of the trigger between the limit and target reference points, the type of control and the minimum effort applied to the fishery (Table 6). Not only were the individual effects considered, but all combinations were tested so that any interactions could be observed.

The plenary of the Fifth CRFM Scientific Meeting in 2009 recommended precautionary reference points to be used to manage the seabob stock. These were used in the management advice provided by the Shrimp and Groundfish Working Group (SGWG; Derrell *et al*. 2009). However, industry, while recognizing the significant risks with targeting MSY, decided to apply a principle of risk. Therefore they decided to use a target reference point such that the stock would have 10% chance or less of being below the MSY level (or spend 10% of years below MSY). This principle, which was felt to be precautionary in this case, led to setting the maximum level of effort at 5100 days-at-sea. This target is less precautionary than that suggested by the Shrimp and Groundfish Working Group (4700 DaS), but more precautionary than the MSY estimate (5660 D-a-S) and consistent with the MSC definition of "highly unlikely" to cause overfishing4. The more precautionary lower exploitation level suggested by the SGWG resulted in higher average stock level, but lower catches (Table 6). Nevertheless, while it was accepted that an MSY target level of fishing was too risky, the stakeholders thought that a defined risk level was better than the arbitrary precaution suggested by the Shrimp and Groundfish Working Group (SGWG) as, among other things, it would link allowable exploitation to the level of information on the stock. The stakeholders however accepted the precautionary limit reference point suggested by SGWG.

Other harvest control rule parameters that were considered (Table 6) were:

1. HCR CPUE Index Calculation: The way the CPUE is calculated was found to be important. The sample/process error is important in making the right or wrong decision from the HCR, but its effect could be reduced by applying a simple moving average calculation that smoothes out the index and reduces its jumping around randomly from year to year. A simple method was applied in this case, but alternative approaches could be tested in future to optimise the method.

2. HCR Trigger Point: The specific placement of the trigger between the limit and target reference point was found to have little impact. The position chosen was the MSY point. This implies that the main focus of the management plan is to maintain the stock above the MSY point, so additional reduction in exploitation is applied to the effort level should the stock fall below MSY.

3. Type of Management Control: The type of control applied could be either catch or effort. Although in theory catches may be less stable, they were allowed to fluctuate based on the estimated CPUE and a fixed effort. The net effect was that applying either a fixed effort or fluctuating catch produced the same result, with fixed effort being only slightly more stable. The choice is therefore reduced to which is easier to enforce, which was the fixed effort control in this case.

4. Minimum Control: The minimum effort level, applied when the HCR CPUE was below the limit reference point, had surprisingly little effect over the values tested. It was also pointed out by the stakeholders that CPUE levels below 10t per trip were probably economically unviable making the minimum effort of academic interest only. Low CPUE levels below 10t per trip remain a distinct possibility (Figure 9), and could result in further target effort reductions in future for purely economic reasons. It was decided to keep a lower limit of zero effort, so that the fishery would be closed should the recruitment be threatened. However, although it was not considered here, the main information is obtained from CPUE, so without at least some fishing effort, no information is obtained on the state of the stock. This will need to be considered on reviewing the HCR.

[4] The HCR was developed and implemented in part to meet the requirements of the Marine Stewardship Council certification programme. The certification attempts to define best practice in fisheries management, which includes a precautionary harvest control rule.

Table 6 Alternative HCR configurations tested and their general results. No significant interaction effects were identified between the various configurations.

Configuration	Options	Result
Reference Point	Precautionary target proposed by SGWG or MSY target	The SGWG target was more precautionary than the MSY target, but there were fewer higher catches.
CPUE calculation	Moving average or Independent annual estimate	The moving average calculation was more stable, with much less chance of overfishing.
Trigger Placement	Close to target Close to limit	There was no perceptible difference between the options. A trigger was chosen at the MSY level as an appropriate point to apply management intervention.
Type of quota	Effort (days at sea) or Catch (kg landed)	There was not much difference as long as catch quota is estimated from the target effort. The fixed effort control gave a slightly better performance, with more stability and higher catches.
Minimum effort below limit	Fishery closed (0 effort) or 20% of the target effort	There was not much difference between 20% and zero effort at the minimum. It is also likely that it will make little material difference. However, the principle on continuing collecting information for the HCR needs to be considered.

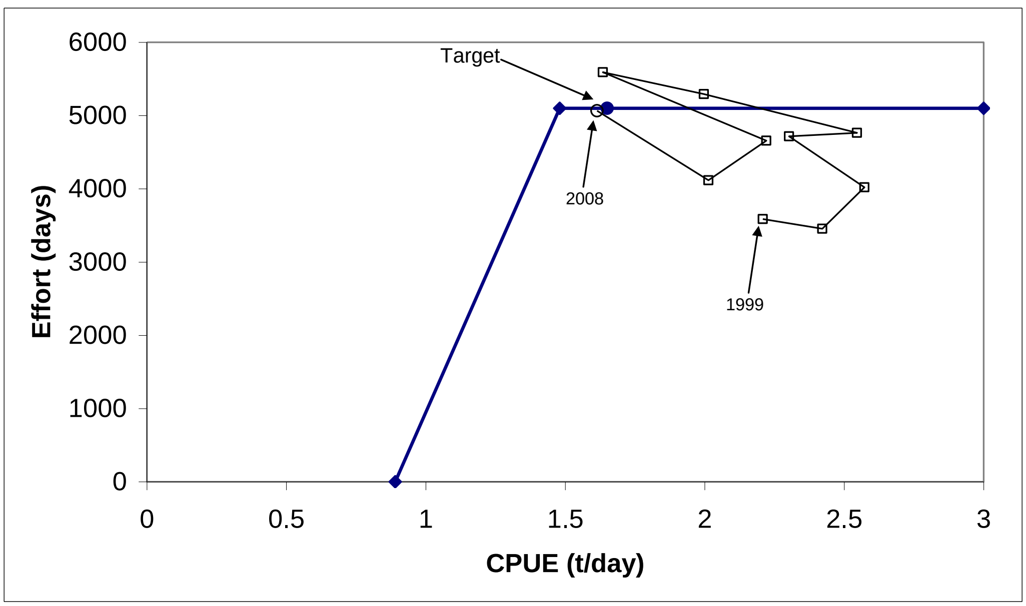

Figure 8 Harvest control rule as agreed for Seabob in the management plan. The recorded total fishing effort and CPUE for years 1999 – 2008 used in the 2009 stock assessment are also plotted. Historically, reduced effort below the target level would never have been applied using this plan. Furthermore, the HCR uses a moving average of CPUE which would dampen the fluctuations. If assumptions are met and target fishing effort has been set at the correct level, it is hoped that reduced effort need never be applied.

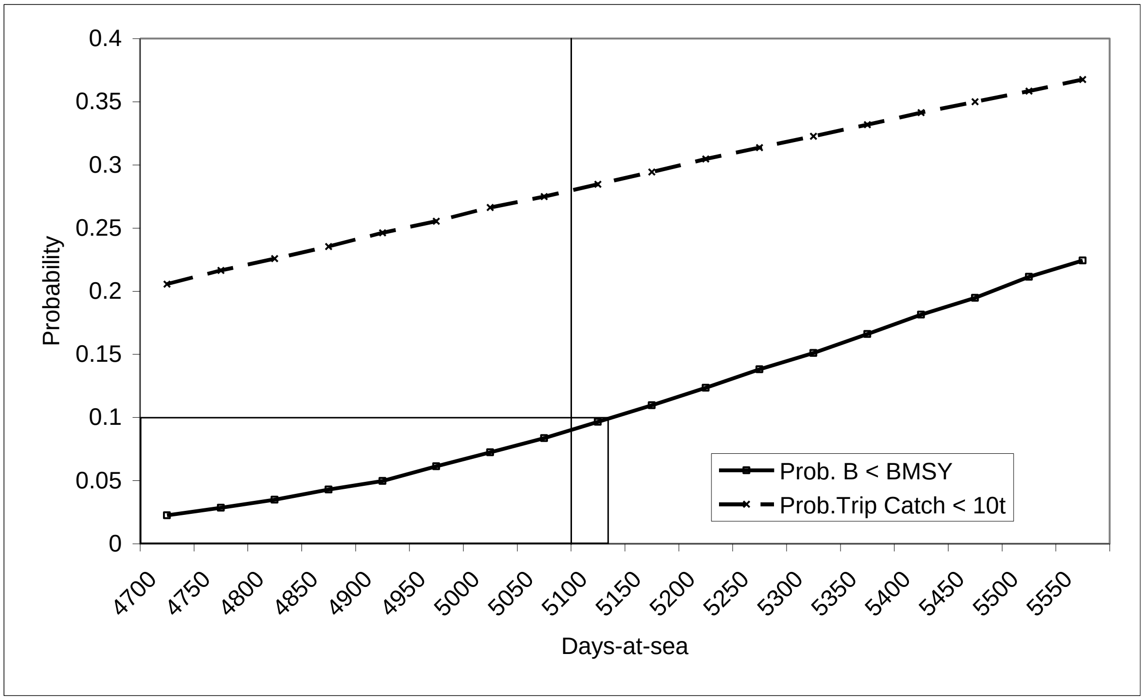

Figure 9 The target level of effort was derived based on a level of risk so that there is only a 10% chance that the level of effort would result in the stock being below MSY. This placed the target, rounded down to the nearest 100 days, at 5100 days-at-sea (centre vertical line). The probability that the catch of a trip is on average less than 10t (break-even point suggested by stakeholders) is quite high at 5100 days-at-sea, but only declines slowly with effort reduction (dotted line).

1.8.5.3 Robustness of the HCR

1.8.5.3.1 Overview

The species life history suggests that seabob will be robust to exploitation as long as there is some on-going monitoring. The monitoring is carried out using CPUE, so it is important to consider whether CPUE is a reasonable index of abundance and how robust it will be when considering various random and other errors, particularly errors in the model structure.

The following is the summary of the evidence that CPUE is a reasonable index of abundance in this case:

- The Government catch and effort data were compared to an index based on raw data extracted from Guiana Seafoods N.V. plant and fleet reports which are used internally. The indices matched showing the same trend. This demonstrated that the CPUE index based on the official Government data was valid and was not invalidated by incorrect treatment or recording mistakes.

- CPUE index observation error needs to be relatively low compared to the information on the abundance. The sampling error can be estimated by random changes year to year in the index, although how this variance divides between sampling and process error is not known.

- The CPUE index shows downward and upward trends consistent with increasing and decreasing catches, suggesting that it is following abundance trends. These trends would probably not be detectable against background noise if the series was hyper-stable.

- There is a strong correlation between CPUE and river outflow in the previous year in Guyana

(Derrell *et al*. 2009). Guyana uses the same gear and fishing operations as Suriname, although they may operate further inshore. If this was the result of changes in catchability an immediate effect would be expected (i.e. this year's river outflow would be correlated with this year's CPUE). This was not the case. A more likely explanation is that river outflow affects recruitment which would cause observed fluctuations in a species which has longevity of a year. Hence, the correlation is most likely to be explained as representing abundance changes rather than other causes.

Although the evidence suggests that CPUE is a reasonable index, it is not overwhelming. In addition, the arguments above do not address concerns with the stock assessment that the population dynamics might change resulting in changing reference points. Ideally, we want a HCR which is robust to inaccuracies in the assessment and to changes which might reasonably occur in the future. This can only be tested at this stage using Monte Carlo simulation.

The harvest control rule is based upon a simple population model, the parameters of which were estimated from fitting the model to the available data. The model was fitted using Bayesian methods, so the results were obtained as the probability of parameter values rather than point estimates. This parameter uncertainty was taken into account, while assuming the model in all other respects was correct, when developing the HCR. It was shown to be robust in this respect (Table 6; Figure 9).

The stock assessment model structure is very simple, representing the main effect of depletion. While more complex models might more accurately capture changes in stock structure, they will always follow the same pattern: higher exploitation will lead to lower stock biomass, while conversely decreasing the amount of fishing will allow stock abundance to increase. The model has a precautionary MSY reference point "hard-wired" into it; that is the MSY is reached when the stock size is at 50% of the unexploited state. It also assumes that CPUE is proportional to stock size. Finally, the model assumes that its structure and parameters remain constant over time, albeit there is a random error associated with CPUE which cannot be explained by the population size or its dynamics.

Given this, there are a number of particular assumptions in the HCR which, if not true, could lead to the HCR failing:

- Sampling and/or process error may lead to poor estimates of CPUE which bear little relation to stock size. In this case, the available evidence suggests that CPUE, while it is associated with a significant observation error, is not swamped by it. In addition, the HCR reduces the effect of error by using a simple smoothing function (moving average). The design of the HCR therefore takes account of the estimated error and this has been assessed as part of its development (Figure 9).

- The CPUE index may be hyper-stable, in that it does not decline linearly with stock size, but at a lower rate (Figure 10). This could allow the stock to be depleted without an indication that this is happening and lead to a sharp, unexpected decrease in CPUE when the stock is close to extinction (i.e. a stock collapse). Hyper-stability is most likely to occur where the stock density remains relatively stable in relation to fishing, either because the seabob itself contracts in its distribution as the abundance decreases, or the fishery serially depletes the stock rather than exploiting it across its range.

- It is possible that the stock productivity changes through time. For example, a correlation between CPUE and river outflow was found in Guyana, which might indicate that production depends on rainfall, which is likely to change with fluctuations in climate. Changes in production invalidate reference points, implying that the biomass at MSY will either decrease or increase over time.

- Changes in catchability may occur with changes in catching efficiency brought about usually by improvements in technology or knowledge of the fishers.

The effects of hyper-stability, trends in the stock productivity and trends in catchability can be tested using simulation. The test is to show whether the HCR is robust to these effects in avoiding overfishing. Clearly, events which occur and are not accounted for in the model will lead to inefficiencies. It is hoped that a robust HCR will protect the stock and the fishery long enough for these events to be detected and included in the stock assessment, so that appropriate adjustments can be made to the management system.

1.8.5.3.2 Simulation Method

A stock assessment, completed in June 2009 (Derrell *et al*. 2009), determined the status of the stock by fitting a stock assessment model to the available catch and effort data. The model was fitted using a Bayesian method which provides parameters as frequencies drawn from the posterior probability density. These frequencies represent the information in the data and "priors" (i.e. the total information on the population dynamics). They account for the uncertainty associated with observation (and process) error in the time series which are manifested in parameter estimate uncertainty. However, while the stock assessment can explain the past, the future has greater uncertainty because many of the parameters which are assumed fixed may actually change.

For each set of parameters, the population based on the logistic model used in the stock assessment was projected forward 100 years applying the HCR. There are 5000 parameters randomly drawn from the posterior of the stock assessment model, so each simulation produced 500 000 observations. As well as the random parameters, an observation error, based on the estimated variance from the observed CPUE, was included in each year of the projection as a random error on the observed CPUE and therefore catch. The projections therefore allow for some process error as the stock size will be affected by this random catch. The projections were undertaken in Visual Basic for Applications within an MS Excel spreadsheet.

The simulation was used to provide three performance indicators, the state of the stock measured as a proportion of the unexploited biomass (which can vary from 0.0 – 1.0), the annual catch and the mean CPUE. In each year of the simulation, the true state of the stock, the total catch and CPUE were recorded and accumulated into a frequency representing a probability density. This provides a convenient summary of the risks associated with applying the HCR under each simulation.

1.8.5.3.3 Hyper-stability

Hyper-stability was represented as a power relationship between CPUE and stock biomass such that:

$$CPUE = q B^a$$

where q = catchability, B = population size (biomass) and a = the hyper-stability constant. If the hyper-stability constant is equal to one, the relationship would be linear as assumed in the assessment, whereas values less than one imply the CPUE index will decline less quickly than the abundance until the stock size approaches zero (Figure 10). The closer the value is to zero, the more extreme the effect, until a=0 when the index does not respond to stock size at all.

Although the CPUE does appear to have declined in a fashion consistent with an approximate linear relationship between stock size and index (Derrell *et al*. 2009), it is also possible that this relationship is hyper-stable and linear only over the range which has been tested. For example, the index is approximately linear for the stock status 0.1 – 0.9 where the hyper-stability constant = 0.2, only exhibiting a strong decline when the stock status falls below 0.1 (Figure 10). While this is possible, it is likely that a low slope associated with hyper-stability is unlikely to be detected as a statistically significant decrease in the index against the observation error, and therefore a hyper-stability constant as low as 0.2 remains unlikely in this case.

Problems with the HCR and hyper-stability depend on the relationship between the CPUE index and abundance being shallow enough that the CPUE does not fall below the trigger point until collapse has occurred. Of the hyper-stability constants, only the lowest value (0.2) seemed to significantly increase the risk (Figure 11). Given this, the HCR does seem reasonably robust to this potential problem.

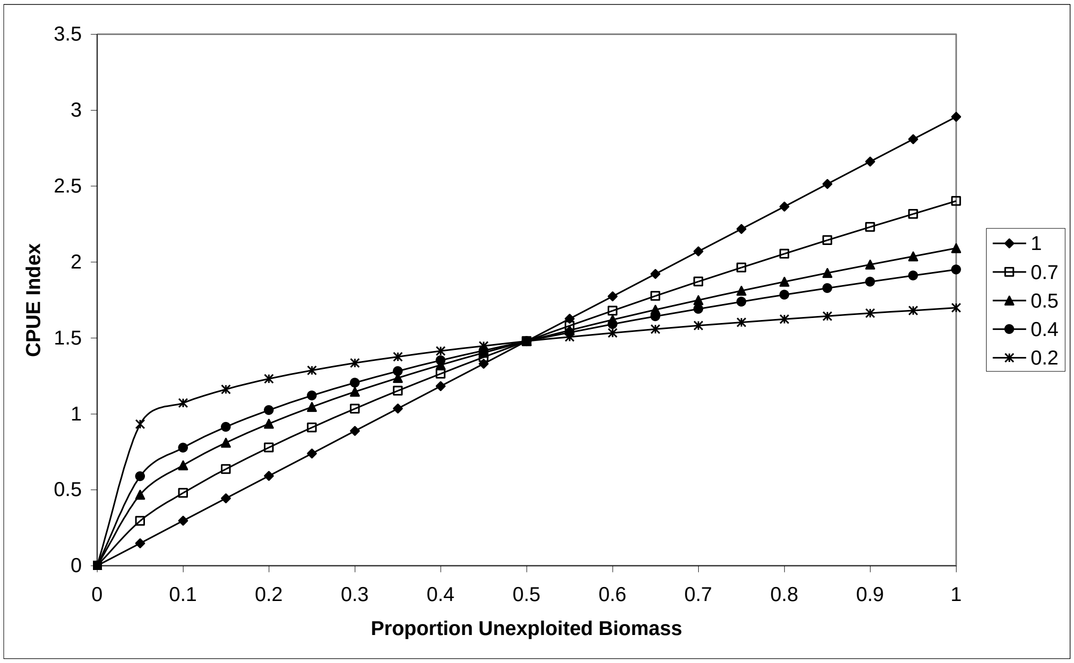

Figure 10 The power function used to represent different levels of hyper-stability in the CPUE index. While in all cases the index declines with abundance, the decline becomes sharper as the index approaches zero for the hyper-stable cases.

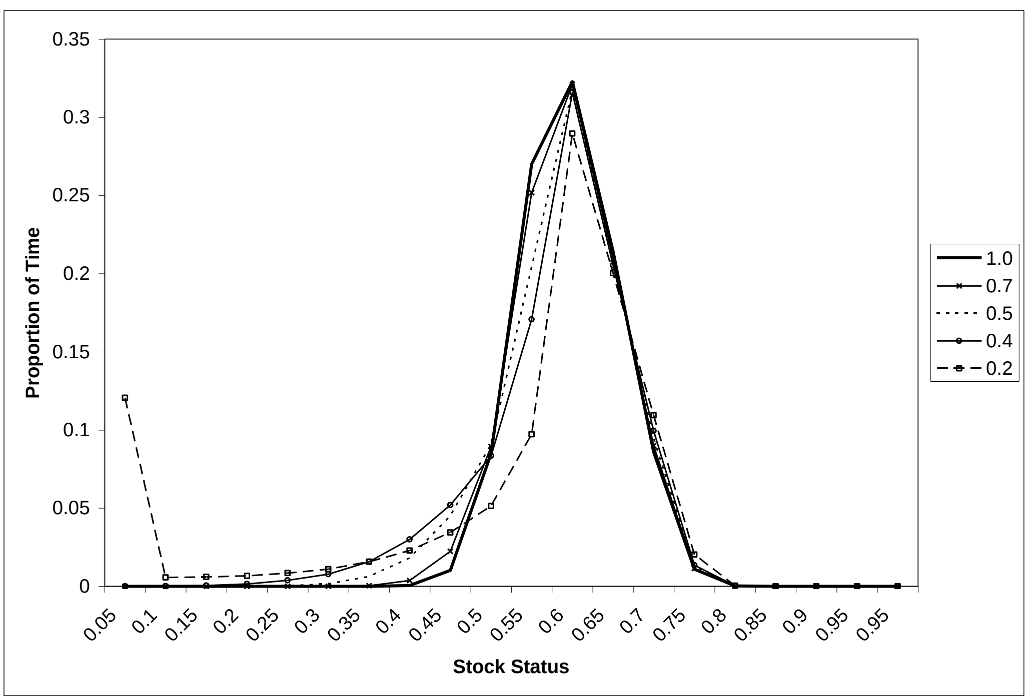

Figure 11 Risks from the CPUE index with different levels of hyper-stability. The stock status is defined as a proportion of the unexploited stock size, which for this model varies from 0 to 1.0, with MSY being 0.5.

1.8.5.3.4 Trends in Productivity

The simulation was applied so that there was a proportion decline (to 0.95) or increase (to 1.05) in the unexploited biomass over time, which would represent a decreasing or increasing level of stock productivity. The harvest control rule was applied without taking notice of the MSY reference point changes which would be occurring with change in stock productivity.

It was found that if the stock declines in productivity and therefore size, the CPUE index would also decline and eventually the fishery closes resulting in the stock remaining at its unexploited size (Figure 12). Conversely, an increasing stock size would result in increasing CPUE, so that the rule reducing fishing effort would never be invoked. This would essentially become a fixed effort fishery with the associated risk that the stock may periodically be reduced below MSY (Figure 12).

A potential problem therefore only occurs if the unexploited stock size becomes larger (Proportional change >1.0). While the biomass is increasing, the MSY reference point, which depends on the unexploited stock size, will also increase so that the status of the stock will decline to around the target reference point, but with no safeguard should the stock fall lower. It is important to note that the biomass under this circumstance would still be very high compared to historical levels.

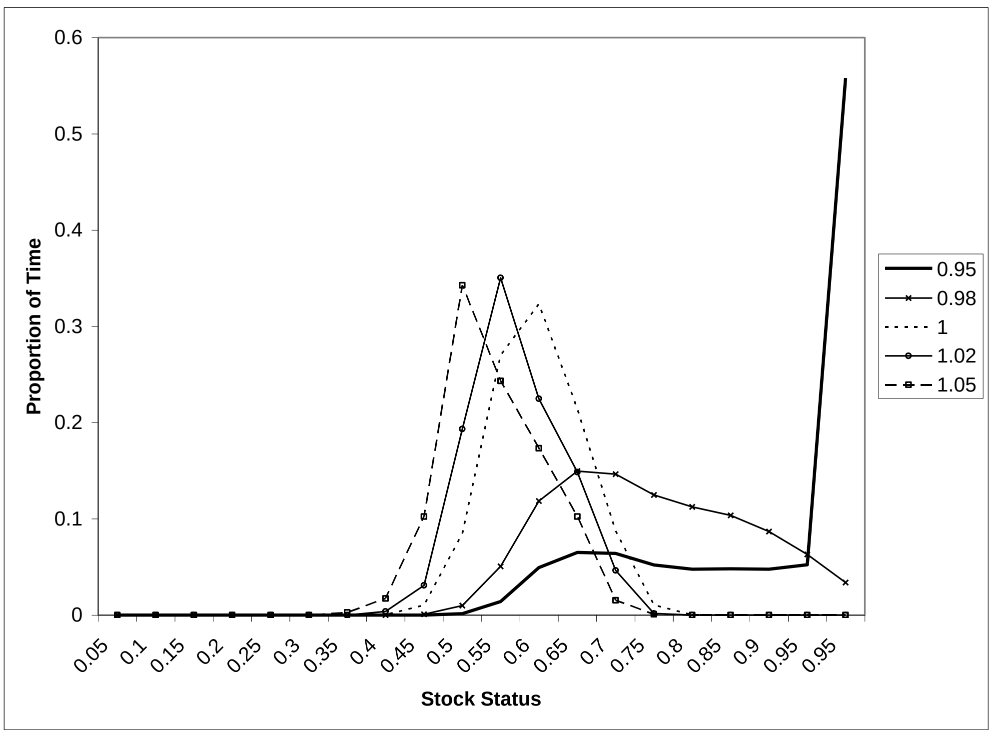

Figure 12 Stock status as a proportion of the unexploited stock biomass for different proportional changes in unexploited stock size (productivity).

1.8.5.3.5 Changes in Catchability

Similarly to changes in stock productivity, changes in catchability were modeled as constant proportional decreases or increases over time. In this case however, results were highly sensitive and the HCR would clearly be invalidated should catchability change significantly. The most likely scenario is that catchability will increase over time with improvements in gear technology, which could lead to very poor performance of the HCR if the reference points are not adjusted as catchability increases (Figure 13). However the worst case, where proportional change in catchability is equal to 1.05, is an extreme example. A constant annual 5% improvement in catching efficiency would lead to a catchability 131 times higher by the end of 100 years, which is not likely to go undetected.

It is quite clear that the HCR would need constant adjustment if catchability is likely to change. For this reason, monitoring has been added to the Seabob Management Plan to ensure any gear changes are recorded and reported.

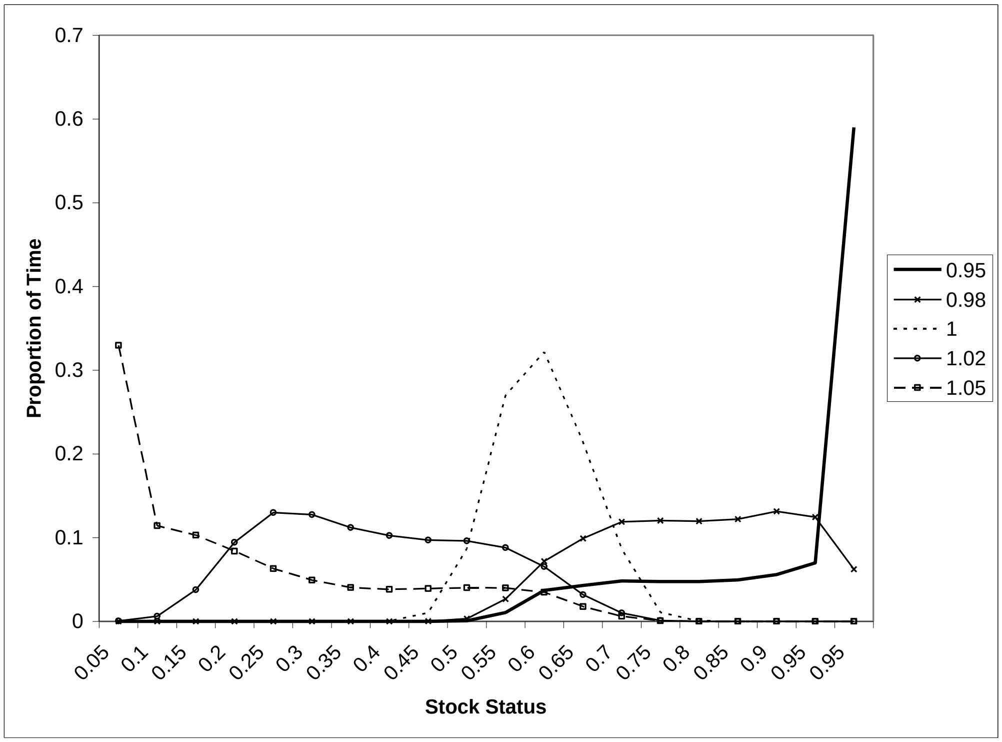

Figure 13 Stock status as a proportion of the unexploited stock biomass for different proportional changes in catchability.

1.8.5.4 Discussion

As a result of the configuration testing, the maximum effort was set to a level between the biomass at MSY (B_{MSY}) and the precautionary level suggested by the working group (120% B_{MSY}). A level was chosen based on clear principles which were precautionary, but had some underlying justification and were acceptable to industry. This was that there was a 10% chance of the stock being below the MSY point for any year taken at random from the simulation (Figure 9). Finally, the limit reference point was defined as that recommended by the SGWG (60% MSY), which should be safe enough for this species.

The simulations applied so far are based on a very simple population model and fall short of a Management Strategy Evaluation (MSE), which would consider more complex population dynamics effects. However, it is likely that under all reasonable scenarios, the two most sensitive issues identified here are likely to remain the ones which will need to be monitored. Nevertheless, a model based on research of the life history could be used to better test the HCR through a MSE.

Under the simulations that have been conducted, the HCR has been shown to be robust, albeit on-going standard monitoring will be required to detect relevant changes to the fishery operations and the stock.

The HCR will be most sensitive to changes in catching efficiency, and therefore this requires special attention in developing the monitoring programme. The recommendations are as follows:

- Hyper-stability: This should be detected through monitoring the spatial distribution of fishing effort based on the VMS output. Hyper-stability would require a contraction of fishing activities over the available area, which annual maps of relevant fishing areas would detect.

- Catchability: The most likely gear changes at least in the short term are introduction and changes to BRDs. These could lead to small decreases in catchability if seabob escape the net, or increases in catchability if more fishing is conducted each day as less sorting on deck is required. This requires monitoring and controlling when vessels have changes to their gear or operations. In addition, scientific advice should be sought before changes are rolled out across the entire fleet. It will be necessary when such changes are introduced, to maintain different sections of the fleet with and without the new configurations so that an unbiased estimate of the change in CPUE can be obtained. More detailed information on fishing operations, such as VMS records, would also be necessary to monitor potential changes in catchability.

- Productivity: While the HCR is robust to changes in productivity, there is potential for improving the economic performance of the HCR if this is better understood. Further work will be undertaken on linking river outflow to recruitment. If a simple relationship is confirmed, this would increase the predictive capability of the stock assessment and allow the HCR to be adjusted should climate change affect the fishery.

- Observation and Process Error: The increasing sampling error with declining fishing effort may cause a problem for the HCR. This has not yet been considered. In the extreme case, if the fishery is closed, no information on the stock would be available. This may require reconsidering the HCR in terms of information which will be obtained from the CPUE index and identifying what minimum level of effort is required to protect the HCR.

1.9 References

CRFM (2009).CRFM Fishery Report - 2009.Volume 1. Report of Fifth Annual Scientific Meeting – Kingstown, St. Vincent and the Grenadines, 09-18 June 2009. 167p.

Derrell, C., Ferreira, L., Medley, P. Soekradj, R., (2009) Report of the Shrimp and Groundfish Resource Working Group (SGWG). In: CRFM (2009) CRFM Fishery Report -2009. Volume 1. Report of Fifth CRFM Scientific Meeting, Kingstown, St. Vincent and the Grenadines, 9-18 June 2009.

2.0 The Shrimp Fisheries Shared by Trinidad & Tobago and Venezuela

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2.1 Management Objectives

The management objective for the shrimp trawl fishery of the Government of the Republic of Trinidad and Tobago is "full utilization of the resource consistent with adequate conservation, and minimal conflict between the artisanal and non-artisanal components of the fishery" (Fisheries Division and FAO, 1992). Within the context of this assessment, the primary objective is interpreted as maintaining the stock size above that required for maximum sustainable yield (MSY).

2.2 Status of Stocks

The overall stock biomass is likely to be stable or increasing. However, local depletion could still be taking place.

The general results indicate the state of the stock is likely to be above maximum sustainable yield (MSY) and the current fishing mortality is well below MSY (Table A and Figure A). The maximum sustainable yield is in the region of 1800 t and catches higher than this will not be sustainable. This is significantly higher than previous estimates (around 1300 t). This is a marked change of status compared to the previous assessment. However, it should be noted that there are severe and increasing limitations on the available data.

It should also be noted that although lower catches in Venezuela (due to the ban on industrial trawling effective 2009) are likely to have benefited the stock overall, it is suspected that parts of the stock in Trinidad will remain depleted. Specifically, although CPUE in Trinidad waters shows a slight upward trend, this is not as significant as that which might be expected given the decrease in catches.

2.3 Management Advice

A harvest control rule should be implemented for Trinidad in order to control the amount of fish caught. At the very least, a fixed seasonal closure of 1-2 months each year, which is considered a relatively crude measure, should be implemented to reduce fishing effort. Projections of biomass and fishing mortality relative to MSY under three fishing effort scenarios, namely zero (representing the current situation), one, and two month season closures are provided in Figure B. The stock is likely to decline below MSY without management action (first scenario) while closures of one and two months greatly improve the likely status of the stock in the medium term, although the resulting levels of effort will likely still cause overfishing in the longer term as fishing mortality is too high.

Table A Results from the stock assessment model fit. The parameter estimates are given at the top of the table, and the more general results at the bottom. Replacement Yield is the catch which is expected to cause no change in the population. The main result is that the stock state is likely to be above the maximum sustainable yield point (B_{2010} status > 0.5; B/BMSY > 1.0).

Parameter	**Percentiles**		
	0.05	**Median**	**0.95**
r	0.25	0.39	0.54
B_∞ (t)	12974	17703	27755
B_{2010} status	0.47	0.57	0.65
MSY (t)	1672	1775	1872
Current Yield		832	
Replacement Yield	1610	1731	1839
B/BMSY	0.93	1.12	1.29
F/FMSY	0.38	0.44	0.54

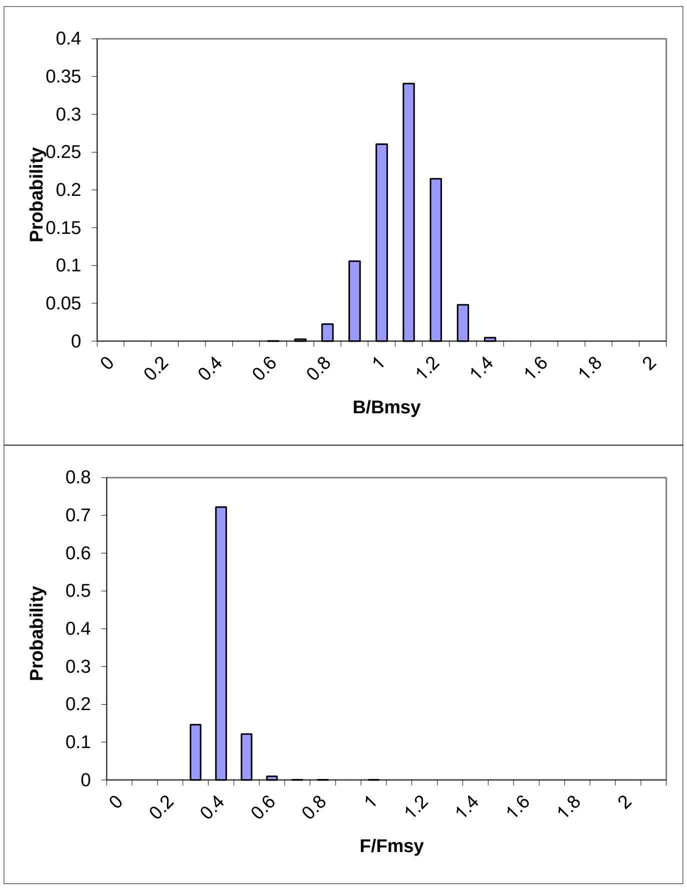

Figure A Biomass (top) and fishing mortality (bottom) relative to the MSY level. The low fishing mortality and high biomass are directly as a result of low recent catches.

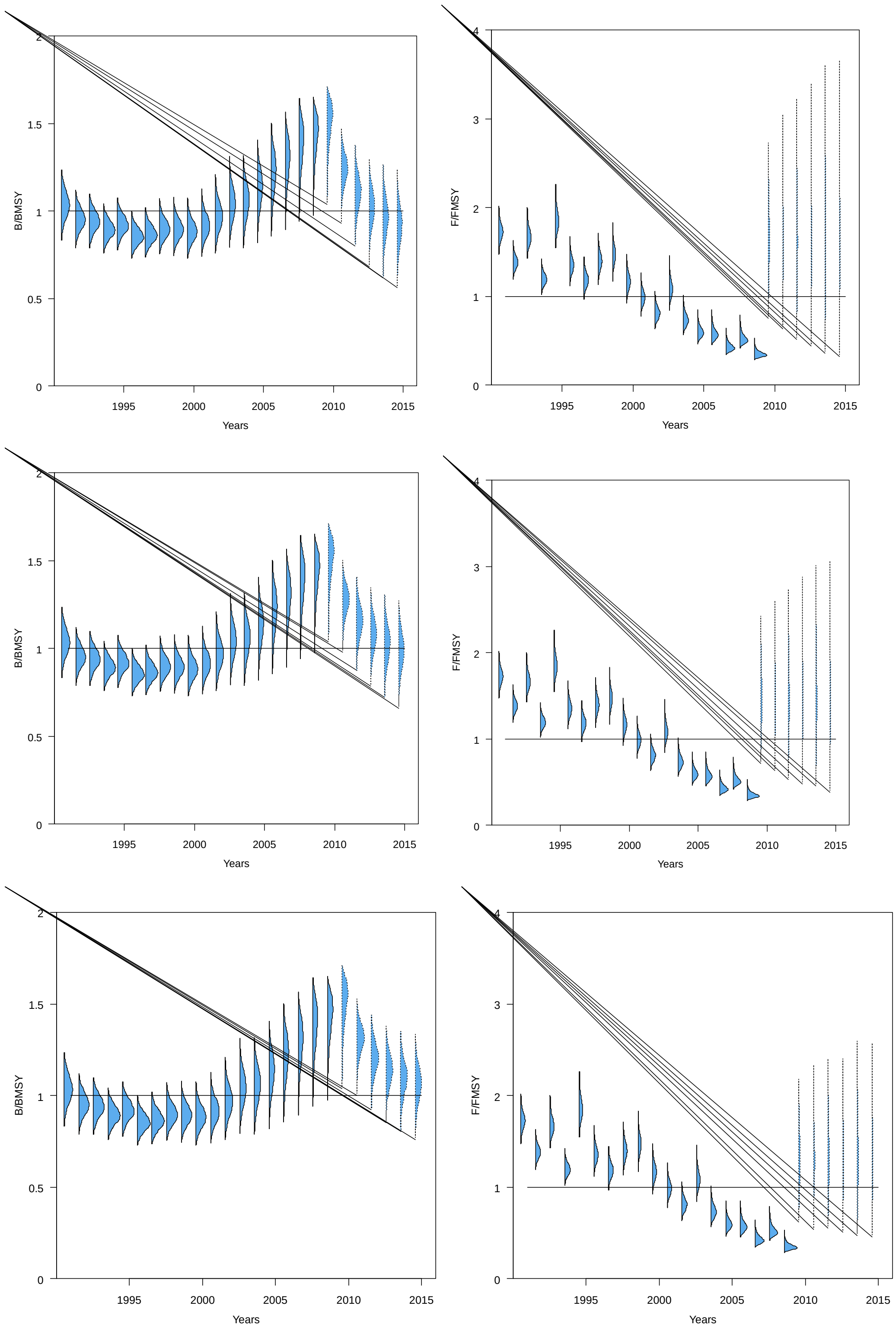

Figure B Projections of biomass and fishing mortality relative to MSY under 0 (top), 1 (middle) and 2 (bottom) month season closures. The shaded area graphs represent probability density, so low flat graphs indicate very high uncertainty, and narrow pointed graphs relative certainty. A dotted outline to graphs indicate they are projections, whereas solid lines are estimates from the stock assessment.

A more sophisticated and complex feedback-control rule, for example, a control on effort in response to changes in shrimp biomass (or a biomass indicator such as CPUE) (Figure C) such that exploitation is reduced as the stock declines, is recommended if the monitoring system can support it. This kind of harvest control rule is more conservative resulting in higher CPUE and biomass (Figure D), but possibly lower catches at least in the medium term.

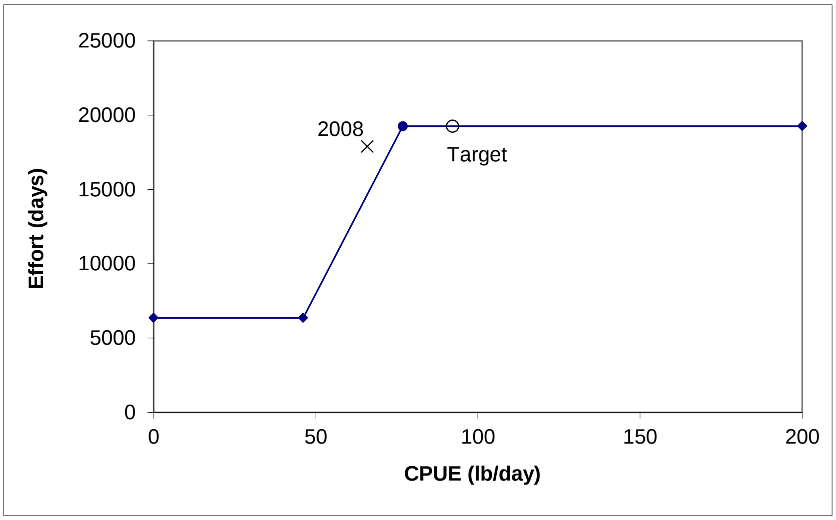

Figure C Possible harvest control rule based on CPUE as an indicator of biomass, and effort in days at sea. If the CPUE drops below a trigger level, effort is reduced according to the line but within a constraint to some minimum level (here 30% of the MSY). The target CPUE and effort based on MSY but with some precaution built in (open circle) and the situation in 2008 (cross) are also shown.

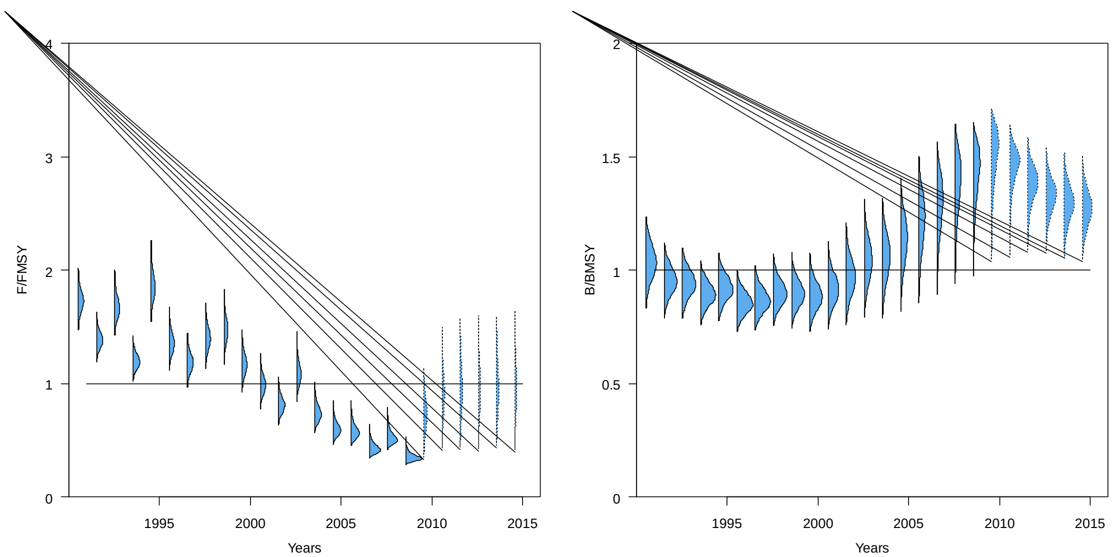

Figure D Results from applying the harvest control rule (Figure C). The stock should be reduced but would most likely remain above the MSY level. This in turn would maintain higher catch rates for the fleet as well as higher catches.

2.4 Statistics and Research Recommendations

2.4.1 Data Quality

1. Implement a Trip Reporting System for the semi-industrial and industrial trawl fleets of Trinidad and Tobago in order to obtain more comprehensive catch and effort records for these fleets.
2. Implement an Observer Programme for the semi-industrial and industrial trawl fleets of Trinidad and Tobago to verify the trip reporting system.
3. Review historical records and consult with Trinidad industrial trawl fleet operators in an attempt to verify or refine shrimp catch estimates prior to the year 2000 when sampling of this fleet was very low or non-existent. Since this fleet takes a large proportion of the total catch, poor estimates will add considerably to the uncertainty of the assessment.
4. Continue and complete computerization of the Trinidad historical catch and effort data from the 1950s to the 1990s. The 1975 base year was important in estimating the unexploited state and hence MSY and the current state of the stock.
5. Structure data collection to allow individual shrimp species to be monitored.
6. Obtain more detailed information, including on species life history, to account for other factors affecting productivity, such as pollution, which was suggested as a contributing factor by stakeholders.

2.4.2 Research

1. Investigate the shrimp stock distribution in Trinidad and Tobago waters. Salinity, water temperature, depth, chlorophyll distribution, shrimp species composition, and any other data which would assist in determining the stock distribution are to be collated.
2. Re-evaluate stock structure as the current assumed structure, effectively a single stock shared between Venezuela and Trinidad, may not be accurate enough to protect fleets from depleting the resources they have access to.
3. Improve the logistic model for the Trinidad and Tobago/Venezuela shrimp fishery as follows:
   - Consider changing catchability due to any shifts from targeting shrimp to targeting bycatch.
   - Include the CPUE standardization as part of the stock assessment rather than performing this outside the assessment and pulling in the results.
   - Estimate the shrimp CPUE for the historical years

2.5 Stock Assessment Summary

The current assessment is an update to that conducted under the FAO/WECAFC ad hoc Working Group on Shrimp and Groundfish Fisheries of the Guianas-Brazil Continental Shelf in 2005 by Medley *et al*. (2006) and updated at the CRFM Scientific Meeting in 2006 by Ferreira and Medley (2006).

A biomass dynamics (logistic or Schaefer surplus production) model was fitted to the available total catch data (1988 to 2009) and the CPUE indices using Bayesian Monte Carlo integration techniques. The CPUE indices were not standardized as this had little effect in previous assessments. Nominal indices were preferred as being simpler to determine and more robust. CPUE indices were still provided separately for the main fleet types which captures the main differences among indices. The model provides advice on a limit reference point, the maximum sustainable yield (MSY). The model requires three population parameters: B_0 = state at the start of the time series, r = the rate of population growth, B_∞ = unexploited stock size, and as many catchability parameters as there are gear types (index series). These were estimated based on the ParFish interviews and converted into prior probability density. The MSY fishery reference point also requires some information on abundance index values when the stock is unexploited. This was achieved by linking CPUE available from all fleets in 1975 to an estimate of stock status at that time, when the stock was thought to be lightly fished.

Utility (relative costs and benefits) for various outcomes which might occur in response to management interventions was estimated from fishers' relative preferences among outcomes, that is, various scenarios of levels of catch (lbs of shrimp) and effort (days at sea) (which could also represent different amounts of income and work) in a month as departures from their current situation. The ParFish interview data thus allowed a review of possible harvest control rules (decision rules which control the amount of fish caught) to identify a set which could be put forward for further discussion. Projections of biomass and fishing mortality relative to MSY were made under zero, one and two month season closures. The default effort level chosen to test the rule was the estimated median observed effort in the time series 1991-2004 (30 750 Type II-equivalent days-at-sea). Therefore, this effort was used in the projection, with the total effort being reduced by $1/12^{th}$ for each month of closure. A harvest control rule based on CPUE as an indicator of biomass, and effort in days at sea was also examined. If the CPUE drops below a trigger level, effort is reduced according to a line (Figure C) but within a constraint to some minimum level (here 30% of the MSY).

2.6 Special Comments

The shrimp stocks of Trinidad and Tobago have, up until now, been assumed to be shared with neighbouring Venezuela. It is however being recommended here, based on the results of the assessment, that attempts be made to re-evaluate the stock structure. It is desirable that scientists from both countries be involved in this exercise. Further, depending on the results of this study, it may be useful for assessment of these stocks to be done jointly with Venezuela with management recommendations being applicable to the fisheries of both countries. If this is the case, then Venezuela should be urged to participate in the CRFM Scientific Meetings or, if this is not possible, to submit the relevant data for analysis as was the case with this assessment.

2.7 Policy Summary

The Fisheries Division is in the process of conducting a review and update of the 2007 Draft Policy (Fisheries Division 2007). The overriding policy objectives are to develop and maintain a cost-effective fisheries management structure, to modernize the legislative and regulatory framework and establish mechanisms for surveillance and enforcement; to ensure the sustainability of the fisheries resources; to promote transparent decision-making and training of stakeholders; to reduce post-harvest loss and promote quality assurance in fish and fishery products offered for local consumption and export; to prioritize the provision of facilities for the fishing industry that meet local and international food safety standards through a system of designated fish landing sites and ensure a safe working environment while considering the socio-economic implications of management measures for fisherfolk; to ensure the integration of fisheries in coastal zone development and provide a mechanism to reduce conflict and facilitate the amelioration of negative impacts due to competing economic activities in the coastal zone; and to protect fishing habitats and address environmental impacts on fisheries.

The Open Access nature of the fisheries is recognized as a critical issue and the policy is to move towards regulated entry, fisheries research and policies for promoting the Ecosystem Approach to Fisheries (EAF) and establishment of Marine Protected Areas (MPAs). For the artisanal fisheries, Government's policy will ensure that any displacement in this fishery as a result of any policy measure should be done in a fair and equitable manner and that those affected continue to earn a decent livelihood; mesh sizes used in gillnets will be increased to reduce the detrimental impact of this net on the inshore fisheries and biodiversity; reduction in bycatch and discards in the demersal shrimp fisheries and the negative impact of trawl gear on the ecosystem will be pursued by the introduction of environmentally friendly gear and enforcement of appropriate management measures.

The Policy promotes collaboration with regional and international organizations for management of transboundary stocks and the establishment of the necessary enforcement mechanisms.

2.8 Scientific Assessments

2.8.1 Description of the Fishery

Shrimp resources in the Orinoco Delta-Gulf of Paria region are exploited by fleets from both Trinidad and Tobago and Venezuela. In the case of Trinidad and Tobago the shrimp is exploited mainly by the trawl fleet which comprises 95 artisanal, ten (10) semi-industrial and 26 industrial trawlers (Fisheries Division records). The artisanal vessels are pirogues 6.7-11.6 m in length with either an inboard diesel engine (90-150 hp) (Type II trawlers) or outboard engines (usually two 45-75 hp) (Type I trawlers). These vessels manually deploy one stern trawl. The semi-industrial (Type III) trawlers are 9.3-12.2m in length with 165-275hp inboard diesel engines. These use a single net operated by a hydraulic winch. The industrial (Type IV) vessels use two nets attached to twin outriggers. The nets are set and retrieved using a hydraulic (double-drum) winch. The vessels are 10.9-23.6 m in length and usually have 325-425 hp inboard diesel engines.

All trawlers operate in the Gulf of Paria on the west coast of Trinidad. The industrial trawlers, and to a much lesser extent the semi-industrial trawlers, also operate west of Saut D'eau on the north coast and in the Columbus Channel on the south coast. The trawl fleet targets: five shrimp species namely *Farfantepenaeus subtilis*, *F. notialis*, *F. brasiliensis*, *Litopenaeus schmitti*, and *Xiphopenaeus kroyeri*; as well as associated groundfish namely *Micropogonias furneri* and *Cynoscion jamaicensis*. Estimated landings for the entire trawl fleet in 2009 were 770t of shrimp valued at TT$25.3 million and 911t bycatch (groundfish) valued at TT$6.6 million. Based on data collected over the period 1992 to 2002, the artisanal fleets operating in the Gulf of Paria catch shrimp species *F. notialis*, *F. subtilis*, *L. schmitti*, and *X. kroyeri* with *L. schmitti* being particularly dominant in the catches from the northern Gulf. Catches from Venezuela by the artisanal fleet from Trinidad comprise largely *F. subtilis* and *L. schmitti*. *F. notialis* is the dominant species landed by the semi-industrial fleet with smaller amounts of *F. subtilis* and *L. schmitti* also being landed. The industrial fleet lands predominantly *F. subtilis* and *F. notialis*.

The Venezuela trawl fishery comprises an artisanal fleet while the industrial fleet has been banned from operating effective 2009. According to Die *et al.* 2004, the artisanal fleet of trawlers comprises 28 wooden vessels (8 m in length with outboard engines) and operates in the northern area of the Orinoco river delta (Pedernales and North Gulf of Paria), while the industrial trawl fleet (which operated up until 2008) comprised 88 vessels (mostly metal vessels 24 to 30 m in length) and operated in the southern Gulf of Paria and in front of the Orinoco river delta. The Venezuelan industrial fleet landed mainly *F. subtilis* while the artisanal lands mainly *L.schmitti.*

2.8.2 Overall Assessment Objective

To measure the impact of fishing on the shrimp population in the Orinoco Delta-Gulf of Paria region using a dynamic fisheries model. The current assessment is an update to that conducted under the FAO / WECAFC ad hoc Working Group on Shrimp and Groundfish Fisheries of the Guianas-Brazil Continental Shelf in 2005 by Medley *et al*. (2006) and updated at the CRFM Scientific Meeting in 2006 by Ferreira and Medley (2006).

The second objective was to use the ParFish interview data in the assessment to develop possible harvest control rules.

2.8.3 Data Used

Name	Description
Shrimp catch and effort data by year, month and trawl type / fishing area for 1988 - 2009, and 1975 for Trinidad and Tobago and Venezuela	In the case of Trinidad and Tobago, catch and effort data were collected by trip on some days (usually 20 random days) for the month at particular landing sites around Trinidad. In order to estimate total catches, these data are first raised to account for non-enumerated days at the site. These first-raised data are then raised to account for vessels at non-enumerated sites. This raising is based on a frame survey of vessels carried out periodically.
ParFish Interview Data	Interviews were conducted in 2008 which obtained information on stock dynamics for use in a Bayesian prior in the assessment and preference scoring data to allow comparison of harvest control rules.

The derivation of total catch (Table 1) and the catch and effort data (Table 2) are described in Ferreira and Medley (2006), with the following changes:

1. For the current assessment the CPUE were not standardized, although the fleets continued to have separate CPUE indices. The standardization had little effect, as it only accounted for seasonal changes in catch rates. It was concluded that while standardization might be desirable, it should be conducted accounting for gear changes and be carried out within the stock assessment.
2. Only three indices were retained, namely Trinidad Type I and Type II, and Venezuelan industrial vessels. For this analysis Trinidad Type III and Type IV, and Venezuelan artisanal CPUE were considered unreliable. Type IV vessels have never had a good CPUE index. Type III also are thought to provide an unreliable index, possibly because the fleet is small, and was excluded in this case again, consistent with previous analyses. Type I was used, but some years were removed. These outliers are thought to represent changes in operation that appears to have affected its catchability, primarily changes in access to Venezuelan waters. In addition, Venezuelan industrial fleet CPUE was only used to 2004 as it was thought to primarily target fish after this point and most recently the fleet has ceased to operate in this fishery. The results are therefore mainly dependent on Type II Trinidad and, before 2004, the Venezuelan industrial fleet CPUE.

Venezuelan catches were reported to Trinidad fisheries scientists, but Venezuelan scientists were not present at the meeting, so issues with these data could not be discussed.

Both Trinidad and Venezuela possess historical catch and effort data for 1975 (Table 2), making this a useful base year. The CPUE for this year was estimated as a proportion of the expected unexploited CPUE (Ferreira and Medley 2006).

Table 1 Estimated catches in kilograms by fleet type. Venezuelan catches are calculated from landings and are probably complete where they are available. Trinidad catches are based on sampled landings raised to total fishing days and total number of vessels.

Year	**Venezuela Artisanal Pedern.**	**Artisanal NGOP**	**Industrial**	**Trinidad Type I**	**Type II**	**Type III**	**Type IV**
1988	0		884993	377678	227444	173462	721435
1989	8334		1086912	165716	163280	108749	517469
1990	2856		1422945	327427	325666	162088	402687
1991	4793		1433005	255965	362023	161824	395858
1992	30499		1162108	139909	256211	93081	312551
1993	144403		1256850	215969	265738	83454	351656
1994	142717		690755	151076	251945	96579	311540
1995	235494		926547	395135	294034	134591	484241
1996	212274	145022	510071	104853	271230	61952	455520
1997	205954	192337	358114	25717	254398	110863	434727
1998	166165	216177	635828	71055	249544	110215	450853
1999	169300	25364	857677	64913	269982	111229	482885
2000	164997	22861	494068	81241	217988	118475	497954
2001	176920	135584	177797	55372	334497	126310	418730
2002	112514	1583	201250	65584	243121	114674	516625
2003	380000	235155	347426	90655	205720	118298	384590
2004	23566	134723	381234	111195	160991	105187	334471
2005	78173	49518	193451	184845	177538	69873	346415
2006	68433	26667	172440	100001	188711	78774	509722
2007	87113	14371	38770	29175	185150	76860	483032
2008	184946	16520	107716	5659	235354	80437	547156
2009	58076	4310	0	367	238826	68149	462290

Table 2 Nominal CPUE indices (kg per day at sea) used in the stock assessment.

	Trinidad		**Venezuela**
Year	**Type I**	**Type II**	**Industrial**
1975	283.284	174.028	179.919
1988			123.413
1989			124.789
1990			107.376
1991			110.138
1992	116.470	66.151	116.771
1993	124.110	64.993	98.484
1994	105.134	56.572	78.043
1995	136.625	63.583	99.117
1996	111.039	68.970	75.824
1997	103.761	73.454	51.512
1998	136.582	56.557	73.345
1999	137.340	53.072	65.352
2000	124.955	41.602	45.071
2001	143.441	51.845	23.438
2002	128.867	53.681	34.378
2003		49.426	49.224
2004		51.078	45.877
2005		48.244	
2006	156.289	58.487	
2007	162.751	47.795	
2008	150.273	65.063	
2009		65.891	

2.8.4 Stock Assessment

2.8.4.1 Objective

To fit a biomass dynamics (production) model to the available total catch data and the standardized CPUE indices using the ParFish priors. The model will allow an MSY reference point to be set to determine whether the stocks are overfished and look at management actions which can be taken to improve the status of the stock and of the fishery, specifically to allow management to consider harvest control rules.

2.8.4.2 Overall Fitting Method

The model was fitted to the available data using Bayesian Monte Carlo integration techniques. The method used was based on rejection sampling using a fitted density based on normal kernel smoothing.

The method has been implemented using Visual Basic in an MS Excel spreadsheet and R through RExcel. While this implementation is numerically slow, it was considered useful in developing the method to use spreadsheet-based functions and data storage as these are most flexible in setting up models and monitoring the behaviour of the fitting algorithm. The full code and spreadsheet are available on request (paulahmedley@yahoo.co.uk). A detailed description of this method is given in CRFM (2008) section 3.8 (St. Lucia conch stock assessment).

2.8.4.3 Model and Likelihood

Consistent with previous assessments, a surplus production model was fitted to the available catch and effort data to estimate the overall shrimp biomass. This model simply describes biomass depletion and growth, without differentiating by species or size. It contains the minimum biological information, but can be a useful empirical description of productivity for providing management advice.

The assessment used the simplest and most commonly used biomass dynamics model, the logistic or Schaefer model, which provides advice on a limit reference point, the maximum sustainable yield (MSY). This limit reference point can be used to restrict the risk of unsustainable fishing to an acceptable level.

In the difference equation form, the logistic fisheries model is written as an equation describing how the population changes through discrete time (annual), as:

$$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{B_\infty}\right) - C_t \qquad (1)$$

$$Y_{gt} = q_g B_t$$

where B_t is the stock biomass at time t, and C_t is all catches combined in the fishery in year t, Y_{gt} = expected index for gear g in year t, and q_g = CPUE scaling parameter or catchability. The model requires three population parameters: B_0 = state at the start of the time series, r = the rate of population growth, B_∞ = unexploited stock size, and as many catchability parameters as there are gear types (index series).

A normal log-likelihood was used to fit the model. There was no evidence for variance change in the series and as the estimated means for the indices were being used, the normal probability distribution was considered a reasonable assumption for the likelihood. Specifically, the log-normal was not found to provide a good description of the index errors.

The MSY fishery reference point requires some information on abundance index values when the stock is unexploited. Although Venezuelan catches exist to 1973, Trinidad catches could only be estimated to 1988, well after the fishery began. Therefore additional information was required to infer the state of the stock in 1988. This was achieved by linking CPUE available from all fleets in 1975 to an estimate of stock status at that time, when the stock was thought to be lightly fished.

2.8.4.4 ParFish Prior

Using nominal CPUE indices, as opposed to standardized indices, allowed the interviews to be used for estimating catchability for the relevant gears. The methodology for ParFish interviews and their analysis is Medley (2003).

Appropriate time, catch and effort units (months, pounds and days-at-sea respectively) were identified and used consistently for all interviews. While this seems obvious, it is a common source of error as, if a fisher is more comfortable with different units, one must remember to convert his answers to a consistent measure. Units should identify those most easily understood by most of the interviewees. For example, a month may be better than a year in terms of assessing catch or effort.

Within the interview, the fisher was asked to estimate:

- Last year's CPUE ($\hat{q}B_{t-1}$) and this year's CPUE ($\hat{q}B_t$) for his main gear,
- The catch rate range he would expect for the unexploited stock (U_l, U_h),
- The time for recovery from the current CPUE to unexploited CPUE (T).

The precise way in which these questions were asked were developed and tested to ensure that the answers were relevant to the parameters being estimated.

The total effort over the last year (f_{t-1}) has to be estimated with additional information. In this case, vessels are registered and total effort was estimated from a standard sampling system.

The individual catch rates were regressed towards the mean of the sample, of fishers interviewed (N). This is necessary as they are used as an estimate for the mean catch rate in the fishery although the question asks for the fisher's own catch rate. For the j^{th} fisher:

$$\left[\hat{q}B_t\right]_j = \left(\left[qB_t\right]_j + \left(\sqrt{N}-1\right)\overline{qB_t}\right)\Big/\sqrt{N} \quad (2)$$

where $\overline{qB_t}$ = mean CPUE of the interviews.

These values can be used to calculate the parameters for each fisher based on the logistic population model. The intrinsic rate of increase (r) can be calculated by solving the non-linear projection equation for the unknown r:

$$X_1 = X_0\left(1+r\left(1-X_0\right)\right) \cdots X_T = X_{T-1}\left(1+r\left(1-X_{T-1}\right)\right)$$
$$X_0 = \frac{\hat{q}B_t}{\hat{q}B_\infty},\ X_T = \frac{U_l}{\hat{q}B_\infty},\ \text{ and } \hat{q}B_\infty = \frac{U_l+U_h}{2} \quad (3)$$

Note that the recovery time is to the lower unexploited catch rate, when the fisher would perceive that the stock has effectively fully recovered. With r defined, catchability can be estimated from the current catch rate and effort adjusted for stock change due to production and catch:

$$\hat{q} = \left(\frac{\left(\hat{q}B_{t-1} - \hat{q}B_t\right)}{S} + r\,\hat{q}B_{t-1}\left(1-\frac{\hat{q}B_{t-1}}{\hat{q}B_\infty}\right)\right)\Big/ f_{t-1}\,\hat{q}B_{t-1} \quad (4)$$

This assumes a linear relationship between catch and effort, but should be an adequate approximation unless fishing mortality is high. The time S allows the time unit to be altered. For example, converting from a year to a month S is set to 12. This allows r to be rescaled between 0 and 2.0. The unexploited stock size can be estimated:

$$B_\infty = \frac{\hat{q}B_\infty}{\hat{q}}, \qquad B_t = \frac{\hat{q}B_t}{\hat{q}} \quad (5)$$

Therefore, for each fisher, estimates of each of the four parameters (r, q, B_t, B_∞) were available. These are converted into prior probability density using non-parametric kernel smoothers. Silverman (1986) provides details on kernel estimators for density functions. The basic aim is to estimate the probability density function from which the frequency has been drawn. There are two requirements. Firstly, a kernel function must be chosen. It has been shown that the particular choice of function is not important in trying to estimate a density (Silverman 1986), so the function can be chosen more for convenience than mathematical requirements. The normal or Gaussian function was chosen for the current model because the multivariate normal can be used for the four parameters and the normal probability is more likely to represent a natural uncertainty among fishers' opinions.

There is no standard method for estimating multidimensional densities. This is achieved here by estimating single smoothing parameters for each of the principle components which are calculated from the data, having zero correlation.

The smoothing parameters generally represent the confidence in the fisher estimates, which is measured by the degree to which the estimates agree. If the answers given by fishers are all similar, there is greater confidence in the interviews and conversely, the more disperse the answers given, the less certain they are. This makes the smoothing parameter estimates more important than otherwise they might be.

Several techniques were used to estimate smoothing parameters for each dimension. A least-squares cross-validation method has the advantage of requiring no user input (see Silverman, 1986). However, although this method is objective, it does not always produce reasonable estimates. Therefore, an estimate was obtained and used assuming the interview answers were drawn from a normal distribution, for which the smoothing parameter (h) could be estimated from the standard deviation (σ) and number of interviews (N):
$h = 1.06\, \sigma\, N^{1/5}$

This was considered safer in the sense that it produced a relatively large estimate decreasing the confidence and therefore the weight given to the interview data relative to the catch and effort data and likelihood.

The prior probability for any set of parameter values could then be calculated as:

$$\Pr(\theta | X, \Lambda) = \frac{1}{(2\pi)^{d/2} |\Lambda|^{1/2} N} \sum_{i=1}^{N} \exp\left(-\frac{1}{2} (\theta - \chi_i)^T \Lambda^{-1} (\theta - \chi_i) \right) \qquad (6)$$

where the covariance matrix (Λ) with dimensions equal to the number of parameters is chosen to smooth the density as described above, θ = vector of parameters for which the prior is being calculated, χ_i = vector of parameters from the i^{th} fisher interview. To make calculation simpler, the probability was calculated for the principle component scores of the parameter values, which were considered independent so the off-diagonal elements in the covariance matrix are zero.

The interviews were separated into Type I/Type II and Type III/Type IV, for which the smoothing parameters were estimated separately, since the catchabilty parameters were different in each case. This assumed an underlying uninformative (and improper) prior on those catchability parameters which were not covered by the interview.

2.8.4.5 ParFish Preference

Statistical decision theory can be used to make rational decisions under risk. As well as the probability, it is necessary to have the utility (relative costs and benefits) for different outcomes. Utility can be estimated from an individual's relative preferences among outcomes. Preference scores were obtained from fishers by getting them to score a set of scenarios representing a range of possible outcomes for the fishery.

The scenarios defined different levels of catch (lbs of shrimp) and effort (days at sea) in a month as departures from their current situation (Figure 1). These could also represent different amounts of income and work, and could be rapidly understood by the fishers.

The scenarios were ranked during the interview using pairwise comparisons (Medley 2003). The difference between sequential scenarios was then scored on a five (5) point subjective scale. The score for each scenario could then be calculated as the cumulative sum of the difference scores between the ranked scenarios. The scores between ranked scenarios are additive, as they are assumed to measure the relative distance along a utility line.

To avoid excessive extrapolation, questions were also asked to constrain utility values within reasonable bounds. The constraints were based on the logistic limit to the amount of catch that can be handled and the effort which can be applied, and lower limit to the utility based on the opportunity cost.

The scores for the scenarios were then modeled using a joint quadratic for the catch and effort values. This built a utility surface for each fisher, which could be used to convert outcomes based on simulating the fishery using outputs from the stock assessment and a harvest control rule into a measure of utility. Essentially, this preference model tried to represent the fisher's views on various possible changes in CPUE, catch and effort which might occur in response to management interventions.

The fisher's current catch and current effort in the preference model is set to 1.0. So the scenario **I** is (1.0,1.0), scenario **G** is (0.5,0.5) and so on. The relative catch and effort for the fishery compared to the present can be calculated from the simulation model. This relative change is assumed the same for fishers. Given the overall catch and effort is set as c_t and f_t as proportions of the current catch and effort at time t respectively, the fisher's score becomes:

$$U_t = \alpha_1 c_t + \alpha_2 f_t + \alpha_3 c_t^2 + \alpha_4 f_t^2 + \alpha_5 c_t f_t \qquad (7)$$

where the parameters are estimated from a least-squares fit to the scenario scores. Graphs of the scores estimated from the scenario ranking method can be found in the software (Figure 2).

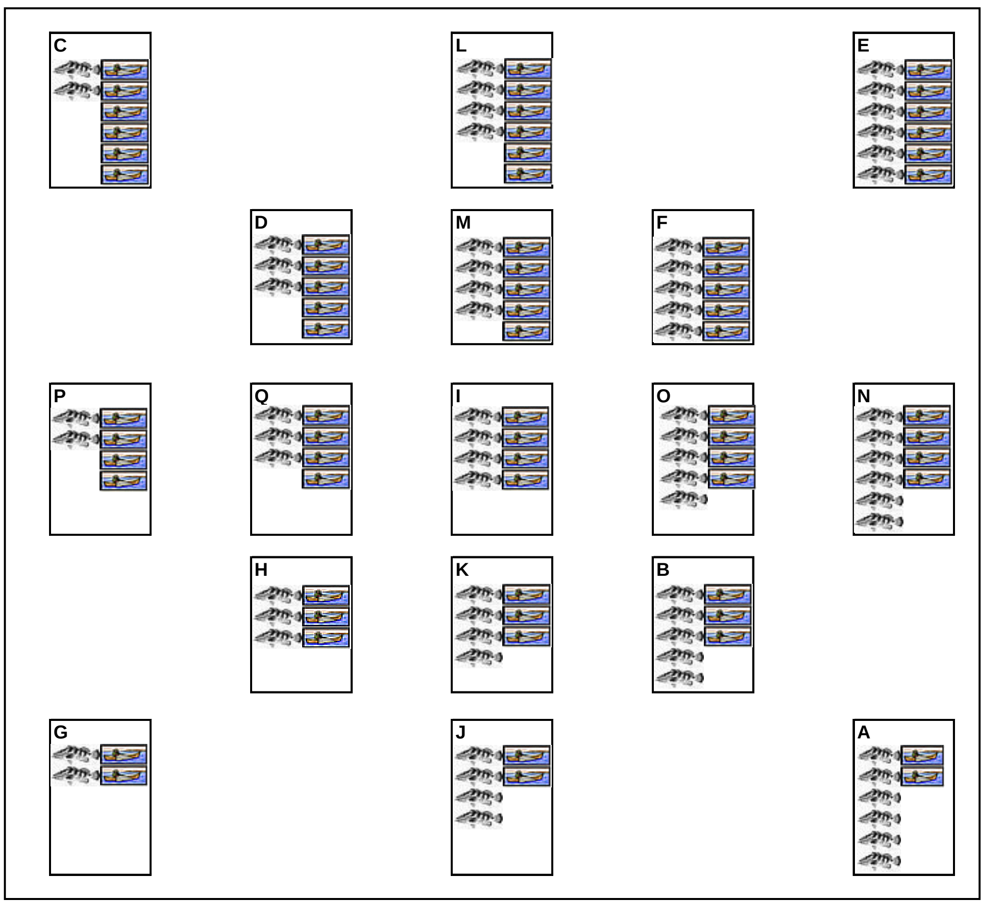

Figure 1 The different scenarios which are used to assess fisher preference. The central scenario I is the current situation with 4 fish and 4 boats representing the current catch and effort respectively in a month. For all scenarios, effort and catch is changed by 25% and 50% around this current value. The scenarios have index letters for easier reference.

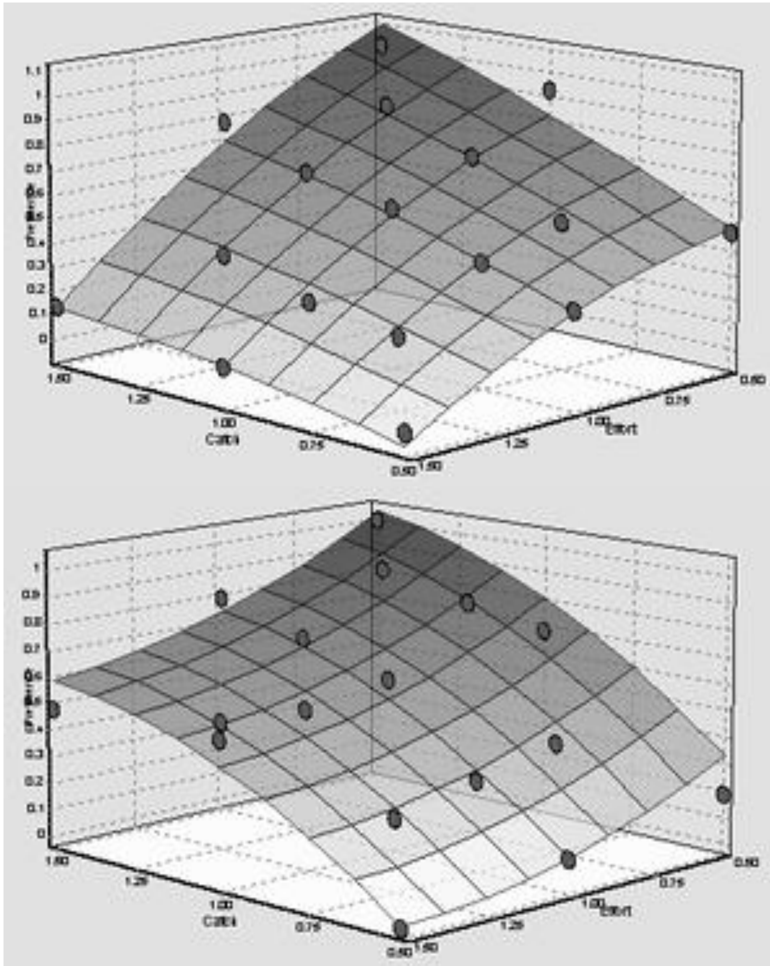

Figure 2 Example preference curves fitted to interview data. In cases of point outliers, the interviewer could check with the interviewee that the scenarios are in the right order. They may also be evidence that the model is too inflexible for good individual curves. The y axis is the preference score. The left x-axis shows catch relative to current catch (1.5 to 0.5 of current catch – a proxy for earnings), and the right x-axis shows effort also relative to current effort (1.5 to 0.5 of current effort – a proxy for costs or work done). The lowest preference score is always for the highest effort and lowest catch.

2.8.4.6 Stock Status

The assessment produced a reasonable fit of the model for the available data with relatively stable results. However, it should be noted that there are severe and increasing limitations on the available data. Catches are not measured exactly, and the CPUE indices necessary to monitor stock status are deteriorating.

The general results indicate the state of the stock is likely to be above maximum sustainable yield (MSY) and the current fishing mortality is well below MSY (Figure 3; Table 3) because recent catches have been low. This is a marked change of status compared to the previous assessment.

The maximum sustainable yield is in the region of 1800 t and catches higher than this will not be sustainable. This is significantly higher than previous estimates (around 1300 t).

Although lower catches in Venezuela are likely to have benefited the stock overall, we suspect that parts of the stock in Trinidad will remain depleted. Specifically, although CPUE in Trinidad waters shows a slight upward trend, this is not as significant as that which might be expected given the decrease in catches (Figure 4). It is likely that not all the areas considered as a single management unit in this assessment are benefiting from decreased exploitation in Venezuelan waters.

Table 3 Results from the stock assessment model fit. The parameter estimates are given at the top of the table, and the more general results at the bottom. Replacement Yield is the catch which is expected to cause no change in the population. The main result is that the stock state is likely to be above the maximum sustainable yield point (B_{2010} status > 0.5; B/BMSY > 1.0).

Parameter	**Percentiles**		
	0.05	**Median**	**0.95**
R	0.25	0.39	0.54
B_{∞} (t)	12974	17703	27755
B_{2010} status	0.47	0.57	0.65
MSY (t)	1672	1775	1872
Current Yield		832	
Replacement Yield	1610	1731	1839
B/BMSY	0.93	1.12	1.29
F/FMSY	0.38	0.44	0.54

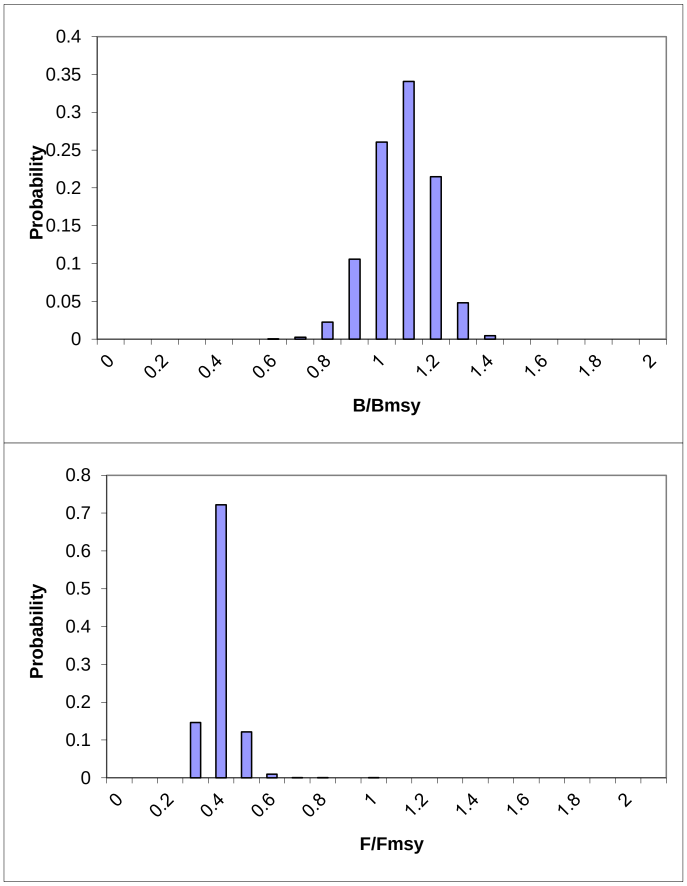

Figure 3 Biomass (top) and fishing mortality (bottom) relative to the MSY level. The low fishing mortality and high biomass are directly as a result of low recent catches.

Figure 4 Observed (points) and expected (line) CPUE for stock assessment model fit for Trinidad Type II vessels.

2.8.4.7 Harvest Control Rule

The harvest control rule is a common term used to describe a decision rule which controls the amount of fish caught. Because it is a decision rule, it can be codified and included in computer simulations based on results from the stock assessment. A very simple fixed decision rule was considered here, but more complex ones are available and should be evaluated, if the monitoring system can support them. In particular, feedback-control rules are recommended as they will cover a wider range of circumstances and can be used to protect livelihoods and food security. For example, a control on effort could be enforced which changes in response to shrimp biomass (or a biomass indicator).

The harvest control rule proposed for Trinidad shrimp is a fixed seasonal closure. For the current stock assessment, the impact of this can only be to reduce fishing effort. Other improvements in size composition that might result cannot be evaluated with this model. The default effort level chosen to test the rule was the estimated median observed effort in the time series 1991-2004 (30 750 Type II-equivalent days-at-sea). Therefore, this effort was used in the projection, with the total effort being reduced by $1/12^{th}$ for each month of closure.

Given that the current effort level is probably well below this level, the projected maximum effort is probably pessimistic. However, the management control should be implemented with the intention of preventing effort reaching these high levels. In addition, Trinidad effort has not been reduced, so local effort may well still be too high, and a closed season may have a positive effect.

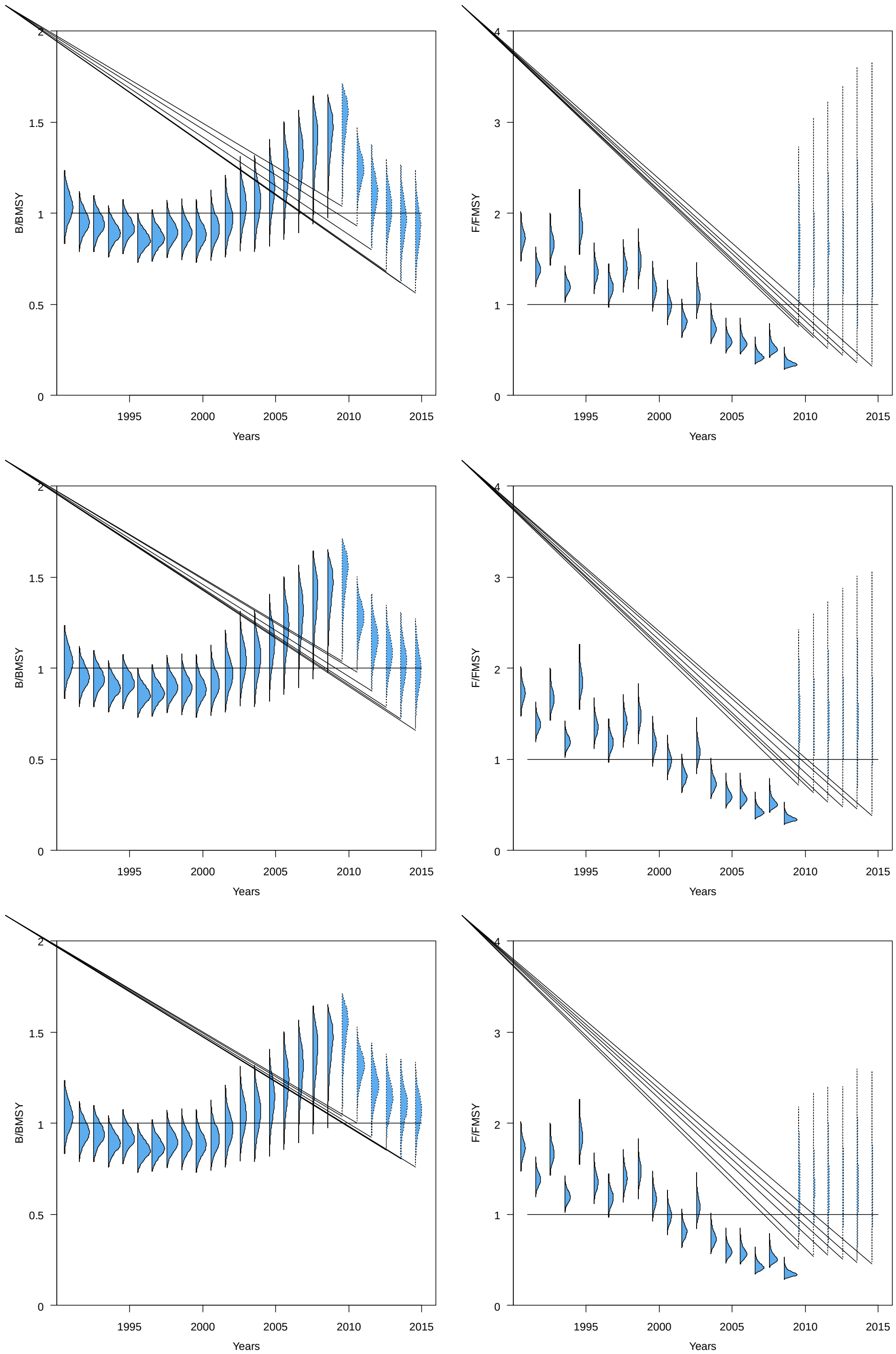

Figure 5 Projections of biomass and fishing mortality relative to MSY under 0 (top), 1 (middle) and 2 (bottom) month season closures. The shaded area graphs represent probability density, so low flat graphs indicate very high uncertainty, and narrow pointed graphs relative certainty. A dotted outline to graphs indicate they are projections, whereas solid lines are estimates from the stock assessment. Note that the projections assume a much higher fishing effort than has been recently observed.

Given that the projected fishing effort is likely to be above MSY (previous assessments have indicated this effort level was too high), the stock is likely to decline below MSY if this effort was applied again (Figure 5). In contrast, closures of one and two months greatly improve the likely status of the stock in the medium term, although the resulting levels of effort will likely still cause overfishing in the longer term as fishing mortality is too high (Figure 5).

As well as considering closed seasons, the analysis also intended to look at using the interview data to review possible alternative harvest control rules. Such harvest control rules should reduce exploitation as the stock declines. The tested harvest control rules set effort just below the MSY level and a safe reduction to a minimum around 30% of MSY level (Figure 6). In contrast with fixed seasonal closure, this harvest control rule is more conservative resulting in higher CPUE and biomass (Figure 7), but possibly lower catches at least in the medium term.

The choice of parameters for the harvest control rule needs to be reviewed by stakeholders, but this will be difficult, time consuming and expensive unless acceptable proposals can be developed beforehand. To make development more efficient, comparison of different parameters for the harvest control rule were made using the preference score. There was only time to consider a set of very limited alternatives at this meeting. Assuming MSY would be the required precautionary reference point, the initial focus of comparisons was on an acceptable minimum fishing effort below which the fishery would not have to fall.

The minimum effort was varied from 0 to 100% of effort at MSY. This suggested higher minimum effort would be preferred, but there was little change above 30%, suggesting this as a useful precautionary value for this parameter (Figure 8).

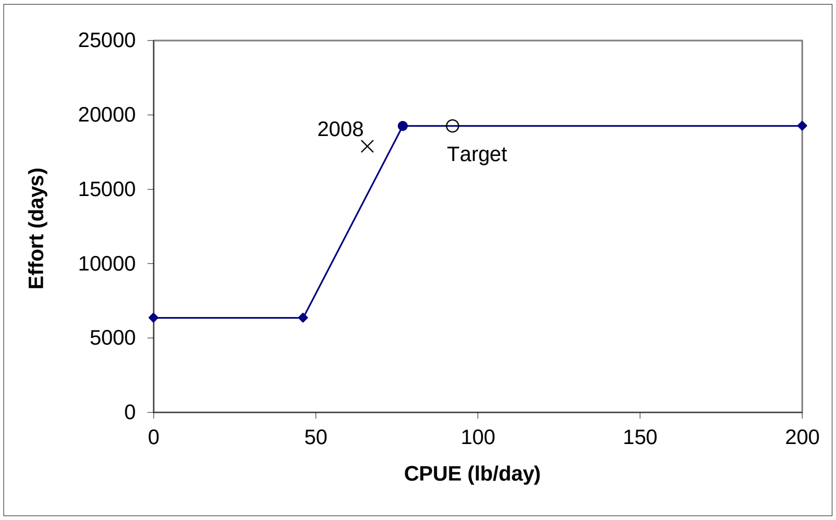

Figure 6 Possible harvest control rule based on CPUE as an indicator of biomass, and effort in days at sea. If the CPUE drops below a trigger level, effort is reduced according to the line but within a constraint to some minimum level (here 30% of the MSY). The target CPUE and effort based on MSY but with some precaution built in (open circle) and the situation in 2008 (cross) are also shown.

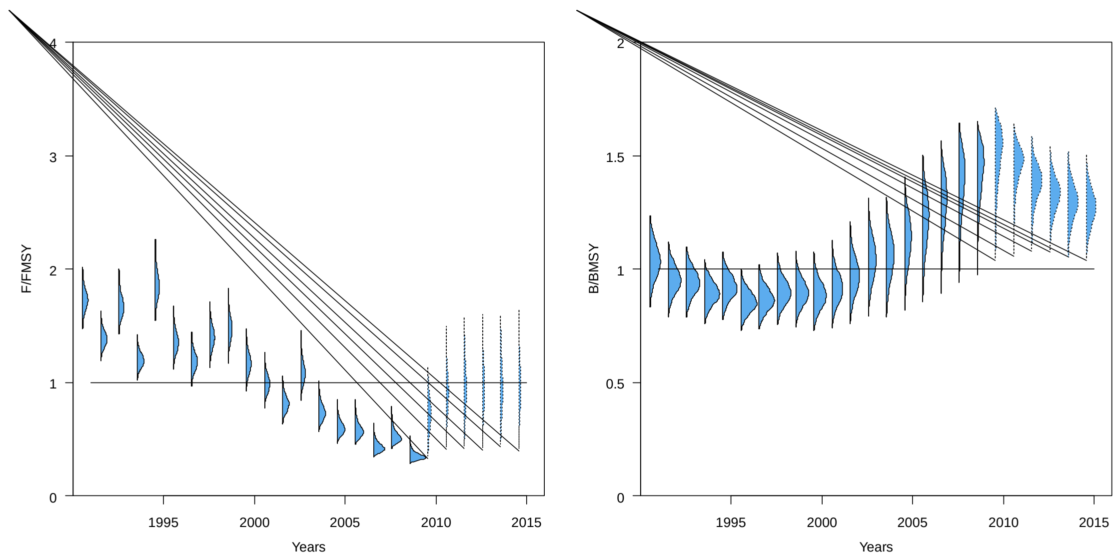

Figure 7 Results from applying the harvest control rule (see Figure 6). The stock should be reduced but would most likely remain above the MSY level. This in turn would maintain higher catch rates for the fleet as well as higher catches.

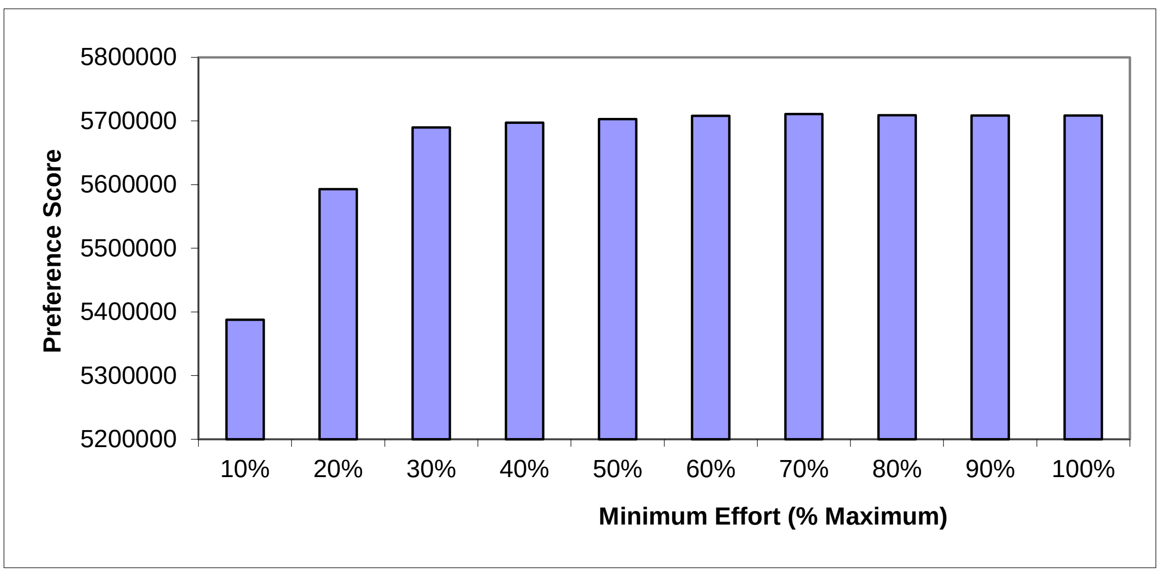

Figure 8 Preference scores for a range of minimum effort levels in harvest control rule (see Figure 6).

2.8.4.8 Discussion

The ParFish interview data allowed a wider review of possible harvest control rules to identify a set which could be put forward for further discussion. It is clear that the fishing industry needs to be protected from uncontrolled falls in catch rates, which currently they are subject to. Developing harvest control rules generally requires participation, but can be difficult. The ParFish methodology allows interview data to be used for participatory decision-making, reducing a wide range of possible harvest control rules to a few which will meet fishers' needs.

The other aim of the analysis was to consider whether ParFish interviews by themselves could be used for stock assessment without the catch and effort data. In this case, the results would have recommended no significant immediate changes since in general the interviews indicate the majority of fishers believe that the stock is productive enough to sustain the current level of fishing. However, the main aim of ParFish would be to persuade the fishery to collect monitoring data, and implement a harvest control rule, so a control would be implemented if the CPUE declined. In this case, such data does already exist so the joint assessment, including both the catch and effort data and interviews should be used.

Currently only a closed season is likely to be possible. This is a relatively crude approach to management, but could still benefit the fishery, preventing long term depletion seen in the past. However, the fishing industry may need to be convinced, since the interviews suggest that they would not expect significant benefits from such a closure. Either the closed season can be imposed, forcing them to try it, or resources are required to convince them it is in their own best interest to close the fishery each year for 1-2 months.

2.8.4.9 Conclusion and Recommendations

The overall stock biomass is likely to be stable or increasing. However, local depletion could still be taking place. Stock structure should be re-evaluated, and data collection structured to allow separate shrimp to be monitored.

The 1975 base year was important in estimating the unexploited state and hence MSY and the current state of the stock. There is clearly a need to continue and complete computerization of the Trinidad historical catch and effort data from the 1950s to the present.

It will be necessary to develop more detailed models, including species life history information, to account for other factors affecting productivity, such as pollution, which was suggested as a contributing factor by stakeholders.

The data now exist to consider more sophisticated harvest control rules (HCR) than a fixed closed season. HCRs can be used to control fishing effort in different areas, greatly improving the economic and social performance of the fishery. However, the main limitation appears to be the management control and fleet monitoring. There has been little improvement in these areas since the last stock assessment. The Type II trawler CPUE index appears to be the only consistent monitoring variable available in the fishery.

Further work is required to develop a management plan for this fishery. Initially it is planned to focus on development of harvest control rules that react to changes in the Type II index. However, a sustainable industry would require further development of the management system, specifically improving data collection. It is particularly important that the monitoring system and management controls account for the true stock structure as closely as possible. We suspect that the current assumed structure, effectively a single stock shared between Venezuela and Trinidad, may not be accurate enough to protect fleets from depleting the resources they have access to.

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3.0 Marine Shrimp Fishery in Kingston Harbour, Jamaica

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Paul Medley, Fisheries Consultant, UK

3.1 Introduction

Jamaica's marine shrimp fishery is primarily artisanal and concentrated mainly in the Kingston Harbour and a few other small near-shore areas especially on the south shelf of the island in areas influenced by high-nutrient run-off. The main species targeted is the Marine White Shrimp *Penaeus schmitti*; however *P. notialis* and *P. brasiliensis* are often captured and recorded in the fishery (Jones and Medley 2000). Shrimp caught are sold locally to householders and a few restaurants at prices often higher than that of finfish (~US$3.6/lb).

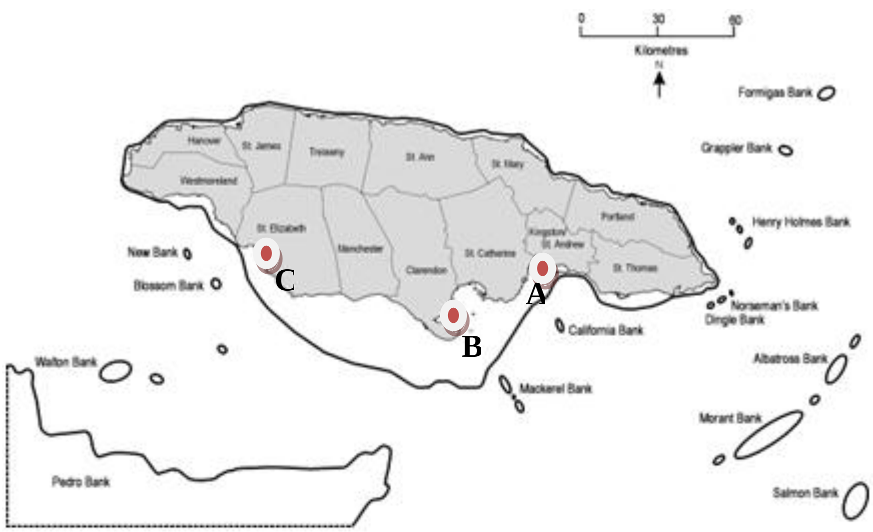

Figure 1. Main shrimp fishing areas of Jamaica; including, (A) Kingston Harbour (B) Portland Bight area and (C) the Black River estuary. (Adapted from Gustavson (2002)).

Within the Kingston Harbour, and indeed other areas, the white shrimp fishery is subsistent in nature and often forms an income supplement for fishers. There are two main fleets targeting shrimp in the; (i) wooden canoes using mono-filament nylon gillnets measuring 1.4–1.9cm mesh size and (ii) fibreglass (FRP) boats using hand operated trawls of 1.9 cm mesh size and powered by 40 HP engines (Galbraith and Ehrhardt, 2000). These gears are usually operated at depths ranging from 10 – 15m. White shrimp are also captured by fishers using seine nets though not specifically targeted.

3.2 Previous Assessments

Since the start of Jamaica's data collection programme there have been at least three (3) attempts at assessing the fishery in the Kingston Harbour. The first of which was completed by Galbraith and Ehrhardt (2000) who looked to analyse data from 1996 to 1999, then in 2000 an assessment was done by Jones and Medley (2000) to develop an appropriate monitoring and management plan. Both reports though providing useful baselines and management recommendations were limited due to relatively poor data and thus were not reliable assessments of the status of the fishery. A third study was done in 2003 to assess the level of compensation to shrimp fishers displaced by engineering works done to develop the harbour. This technical report also could not come up with a reliable model for either production or economic earnings due to a poor data set.

3.3 Management

3.3.1 Management Objective

The management objective for the Jamaican white shrimp fishery is to promote and ensure stock sustainability, efficient utilization of the stock and sustainable livelihoods.

3.3.2 Data Quality / Monitoring

Jamaica has been collecting catch and effort data by gear for the Kingston Harbour area and other landing sites around the island since 1996. The shrimp sampling plan, which is still in place, requires also the collection of monthly biological sampling. Due to various resource constraints, the type and quality of data collected has been seriously compromised partially resulting in a lack of meaningful assessments being done on the fishery, and by extension, the type of management intervention that can be implemented.

3.3.3 Environmental and anthropogenic issues affecting the fishery

There are a number of environmental and man-made factors that are presumed to have serious effects on the white shrimp stock, particularly in the inner bay (Hunts Bay) and outer areas of the Kingston Harbour area. This has serious implications for management since many factors external to the fishery are believed to affect the size and availability of the stock; however this will need to be confirmed by the appropriate research. The Kingston Harbour is a sink for both natural and artificial drainage systems including at least two relatively large rivers and several gullies and conduits which release significant amounts of land-based nutrients in the area. The harbour also facilitates a relatively high volume of marine vessel traffic and their associated activities; such as the release of bilge and wastes which may be impacting the stock and may need to be assessed. The fishery is also impacted by occasional engineering work to develop and maintain the harbour. As recent as 2002 a large dredging exercise in the harbour caused significant negative impacts on the livelihoods of shrimp fishers in the area.

3.4 Review Summary

The objective of the current assessment was to examine the current catch data set (1996, 2000-2010) and decipher trends given the data’s limitations.

3.4.1 Catch trends

Figure 2 below shows the total reported monthly catch of white shrimp landed per year at Hunts Bay (Kingston Harbour) 1996, 2000-2010. There are many instances of incomplete data for each year. Monthly landings are relatively low, fluctuating generally just below 10kg/month with very little variation.

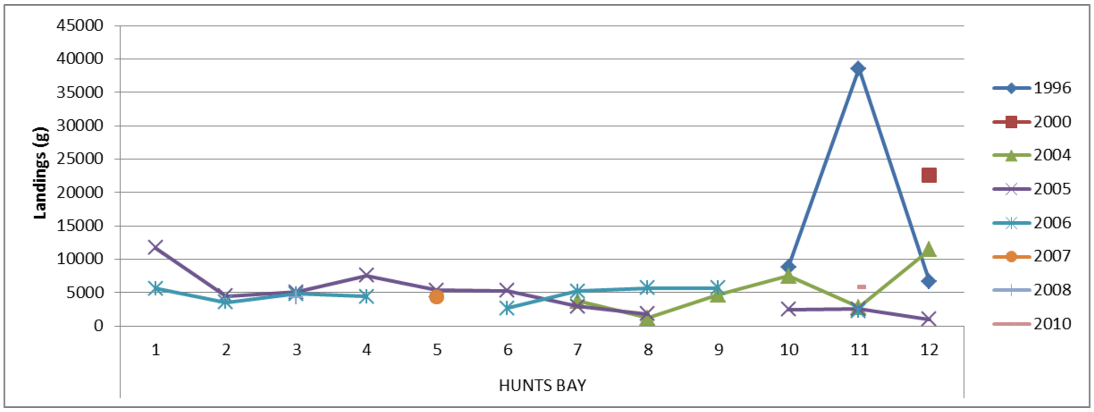

Figure 2. Total reported monthly landings of white shrimp caught per year at the Hunts Bay fishing beach (Kingston Harbour) 1996, 2000-2010.

Figure 3 below compares the reported annual landings of white shrimp at Hunts Bay by gear type. Here the main trend seen is that trawling gear (TRWL) generally lands a larger quantity of shrimp versus other gears, notably gill/china net (CHNE).

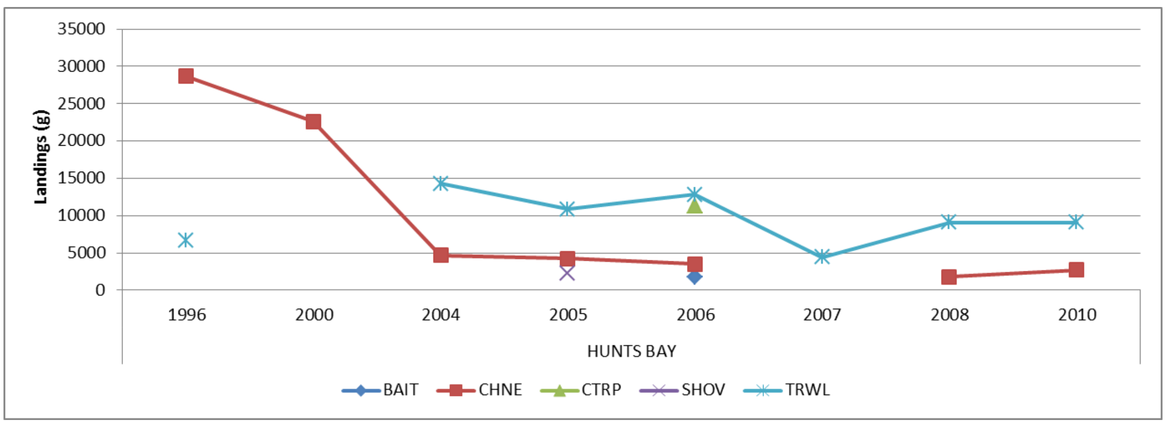

Figure 3. Annual landings of white shrimp caught using various gear types (BAIT – bait net, CHNE – gill / china net, CTRP – crab trap, SHOV – shove net and TRWL – trawl) at the Hunts Bay fishing beach (Kingston Harbour).

3.5 Recommendations

The following recommendations are put forward as a guide to developing the fishery as a whole and meeting the management objectives of the fishery.

- Resources must be found to develop the Jamaica's white shrimp data and carry out the activities of the sampling plan. This should be geared toward developing the data set for regular stock assessments.
- Conduct an independent monitoring of white shrimp catch rates in various areas within the Kingston Harbour (and possibly other areas) to determine the status of the stock and explore alternative fishing areas.
- A programme must be put in place to obtain a socio-economic baseline which will complement the biological data for the fishery. This baseline must include, but not be limited to; the number of active fishers and vessels per year, earning per fisher/boat, basic household information, the degree of importance of the fishery (economic and nutrition), operating costs of fishing
- Include relevant areas of the above recommendations in a management plan for the fishery and also legislative regulations.

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Annex 1: Marine Stewardship Council (MSC) Certification for the Suriname Seabob Fishery: Characteristics and Progress

Situation in 2007:

-> negative publicity concerning TROPICAL SHRIMP

red-listed by Greenpeace

red-listed by WWF

-> European retailers start “removing tropical shrimp” from their shelves.

Morubel’s (part of the Heiploeg group) response to this was a project called “HAPPY SEABOB”
Important in the Project Happy Seabob was to look at:

- quality,
- social responsibility,
- sustainability and
- ecology.

With the final aim for sustainability and ecology the MSC certification for Suriname and Guyana seabob started.

But what was the situation at that moment in Suriname?

- No morphometric data and insufficient stock data for a stock assessment
- A Fisheries Management Plan remaining in draft for 8 years
- The shrimp boats only have TEDs, no BRDs
- No code of conduct for the boats
- No transparent decision making processes in fisheries management
- Weak monitoring and control at sea

MSC (Marine Stewardship Council)

- the MSC standard is internationally recognized
- the MSC standard complies with the FAO Code of Conduct for Responsible Fisheries
- the MSC standard provides a useful audit tool for identifying weaknesses in fishery management systems
- MSC certification is being increasingly used by the supply chain (processors, food service sector and retailers) as part of their preferred specification when sourcing product

The MSC standard is based on 3 principles:

P1 – Species / stock
Harvest strategy / management

P2 – Environment
Bycatch and discards
Endangered, Threatened and Protected (ETP) species
Habitat
Ecosystem

P3–Fishery management
Governance and policy
Fishery specific management system

Evolution towards pre-assessment

- Start sampling plan for morphometric data end 2007 (Suriname & Guyana)
- First contacts with FAO for bycatch reduction program for Tropical shrimp fisheries.
- Beginning of 2008 start data collection for stock assessment (using morphometric data and Government landings and effort data)
- 2008 start up of bycatch monitoring and testing with BRDs
- Contacting and informing identified stakeholders: meeting WWF with ML Felix. Meetings with Government department responsible for fisheries (LVV) at all levels and with Minister

Result of Pre assessment: January 2009

Major items raised:

- Stock assessment needed: insist with the Governments to take raw industry data together with data reported to Government to CRFM for stock assessment
- Fisheries management plan not in place
- Need for Code of conduct for the boats
- Installment of bycatch reduction devices and further testing
- Suriname was considered ready for assessment, for Guyana this would take more time.
- The Heiploeg Group concentrated on Suriname for MSC certification but continued the preparation path in Guyana simultaneously, for stock assessment, BRD, Code of Conduct, but not on the P3 (fisheries management) matters.

Preparing for assessment 2009

- Morphometric data and stock data provided to Suriname and Guyana Governments to be taken to CRFM for proper stock assessment
- Approaching Namoona to involve the whole seabob industry in MSC certification.
- Put in place code of conduct for the whole fishery
- Installation of BRDs on the whole fleet and further monitoring
- Output from CRFM was used to make Harvest Control Rule, part of the outline for seabob management plan.
- May: Announcement of MSC assessment for the whole Suriname seabob fishery
- November site visit

Further improvements in 2010 / 2011

- Transparent decision making: Creation of Seabob Working Group (SWG), with involvement of LVV, industry, artisanal fishery and representative of Fishery Advisory Board. Consultation from WWF.

  Main task of the SWG: evaluation of catching data and follow up of CPUE, evaluation of scientific tests, safeguarding of the requirements set in the Fishery Management Plan.
- Creation of Fisheries Management Plan for Seabob
- Further elaboration of code of conduct on the boats including full ETP strategy : registration of ETP encounters, how to handle them, identification, “move on rule”[5], training for the crew
- The FAO bycatch reduction program started and improved BRD may result from this
- Testing with lighter gear was done at end 2010. This may lead to less fuel consumption and less seabed interaction.

[5] A “move on rule” is one that applies to the fishing vessel, usually to avoid bycatch. The rule defines when a vessel will be required to move its fishing operations some minimum distance during a trip.

- Development, approval, responsibilities and follow up of Research and Development Plan for the Seabob fishery
- PHD student will be allocated to guide a project for habitat impact and role of the seabob in the ecosystem.

MSC Certification was awarded to Suriname Seabob in 2011.

Appendix 6: Report of the Large Pelagic Fish Resource Working Group (LPWG)

Ms. Louanna Martin – Trinidad and Tobago (Chairman)
Ms. Yvonne Edwin – St. Lucia
Ms. Kafi Gumbs – Anguilla
Mr. Crafton Isaac – Grenada
Ms. Cheryl Jardine-Jackson – St. Vincent and the Grenadines
Dr. Freddy Arocha – Instituto Oceanográfico de Venezuela-Universidad de Oriente (Venezuela)
Mons. Lionel Reynal – IFREMER (Martinique)
Ms. Nancie Cummings – NMFS, SEFSC (Miami, FL, USA)
Dr. Todd Gedamke – NMFS, SEFSC (Miami, FL, USA)
Sr. Manuel Perez – OSPESCA (El Salvador)
Ms. Lara Puetz – Intern-CIDA/Dalhousie University (Canada)
Dr. Susan Singh-Renton – CRFM Secretariat

A. OVERVIEW

Review of inter-sessional activities since last meeting, including management developments during this period.

Attempts were made to obtain blackfin tuna data from Cuba, Dominican Republic and Columbia as recommended by the LPWG at its 2010 meeting. Catch data were submitted by the Dominican Republic, however, they expressed a lack of confidence in the data. Data were not received from any of the other countries.

Review of blackfin tuna fisheries, data and information and trends

Catch, catch rates, stock structure and information on the biology of blackfin tuna were reviewed at the 2010 LPWG meeting. The findings are documented in the 2010 report of the WG.

Review of commitments to the CLME project

The group agreed to prepare for the CLME project, information packages on dolphinfish and blackfin tuna which will include information on the fisheries in Venezuela and the French West Indies.

In order to address the data improvement component of the CLME project commitments the CRFM Secretariat is implementing an ERAEF on dolphinfish. The group agreed to work towards completing the assessment to the SICA/Stage 1 level at the meeting. The ERAEF is expected to highlight data requirements based on identified operational objectives not only for stock assessment but also to meet the demands of EAF.

Recommendations

The members of the group expressed their frustration at not being able to access, at the meeting, all of the data and information presented at the 2010 meeting. As a result the group recommended that a data repository be established for all data and information, including presentations and papers, submitted to the working group for its work. Given the issues of confidentiality involved, a server allowing for the application of restrictions would be required in addition to a part time server manager. In this regard it is recommended that the CRFM position of Program Manager Statistics and Information be filled and that a data policy be adopted by the CRFM. The working group opened a 'Dropbox' to allow for the sharing of data and information among members of the group in the short term. It was recommended that read-only documents be shared in the Dropbox.

Review of management objectives and management strategies – i.e. review of fisheries

Group members present indicated that the same general objectives applied for all of their fisheries and that the operational objectives identified in the ERAEF were applicable to the management of the fisheries. It was agreed that the sub-components of the dolphinfish fisheries most at risk from fishing were population size and behaviour/movement of the population. These sub-components were also found to be applicable with respect to other pelagics fisheries. It was agreed that in relation to addressing the maintenance of population size, the most appropriate management action/operational objective would be to maintain biomass above a specified level. With respect to addressing behaviour/movement of the population, the management action/operational objective identified was to ensure that the behaviour and movement pattern of the population do not change outside acceptable bounds.

Consideration was also given to the types of management measures that would be most suitable for pelagic fisheries in the region given their complex nature in terms of the simultaneous targeting and capture of multiple species, the simultaneous use of multiple gears, and the limited availability of resources for monitoring and enforcement.

Recommendations

Given the general characteristics of the fisheries it was felt that catch limits would be very difficult to monitor and enforce; their use therefore was not likely to be successful. It was agreed that effort limits and size limits would be more appropriate.

Review of selected fishery to be assessed – i.e. review available updated data and information, including review of national reports, fisheries

An ERAEF scoping analysis was completed for the dolphinfish fishery. This involved the development of a profile of the fishery, establishment of the units of analysis or lists of species, habitat and communities involved in the fisheries. With respect to the species lists, target, target bait, by-product/by-catch and threatened, endangered and protected (TEP) species were identified.

For the assessment of the blackfin tuna fishery, catch and effort data were submitted by St Lucia, St Vincent and the Grenadines, Trinidad and Tobago, Jamaica, the French West Indies and Venezuela. The French West Indies also submitted species composition and length frequency statistics. Venezuela submitted CPUE and size statistics.

The St Lucia data were individual trip records for the period 1995 – 2009. The data included weights of all species caught and measures of effort (soak time, gear quantity and crew size) by gear type. The data submitted by St Vincent and the Grenadines were 2455 individual records for trips in which blackfin tuna were caught over the period 1984 – 1994. Species weight and value, and crew size and soak time among other measures of effort, were included by gear type. The data submitted by Trinidad and Tobago were 7385 records of individual trips in which flyingfish, dolphinfish and blackfin tuna were caught in Tobago for the period 2005 – 2010. The data included species weight and price, and number of crew by fishing method. The data submitted for the French West Indies included catch series for Martinique and Guadeloupe for dolphinfish and blackfin tuna for the period 1985 – 2009 and estimates of CPUE by gear for the years 2009 and 2010. The data submitted for Venezuela included blackfin tuna catch series and standardised CPUE for the period 1988 – 2009 and size data by fleet from 1993 to 2010.

A description of the blackfin tuna fisheries of Venezuela was presented, which highlighted fishing areas of the different fleets, preliminary catch and effort analyses by fleet, diagnostic analyses on the data, and blackfin tuna size structure analyses for the bait boat and purse seine fleets.

Information was presented on the impacts of FADs in pelagic fisheries in the French West Indies. The structure of pelagic species populations around the FADs was highlighted and research being implemented and planned based on the use of FADs was introduced to the working group. Information was also presented on the identification of small tunas as developed in the French West Indies. JICA's collaborative work with the CRFM in the region on FADs fisheries in Dominica and St Lucia was mentioned in addition to French West Indies's/IFREMER's plans to work with Dominica on FADs fisheries.

Recommendations

- Regional studies on reproduction and genetics with respect to blackfin tuna and the identification of small tunas (especially blackfin tuna and yellowfin tuna) should be considered by the working group.
- Grenada should computerize catch and effort and other fisheries related data.

Fishery data preparation, analysis and assessment planning and implementation, and report preparation

With respect to the ERAEF of dolphinfish, the group engaged in determining the most appropriate management objectives for the fishery. These included core objectives (what is trying to be achieved) and operational objectives (how to measure achievement). Additionally, the hazards of fishing and external activities within the fishery, leading to the potential harm of the components assessed in the ERAEF analysis, were discussed and reviewed. Finally, the Level 1 Scale Intensity and Consequence Analysis (SICA) was commenced and SICA tables for two out of the five ERAEF components were discussed and completed.

Based on consideration of the data submitted it was decided that an assessment of blackfin tuna could not be attempted at this meeting. It was agreed that a case study on catch standardization using the St Lucia data would be attempted with the aim of addressing the issues of improvement of data collection and reporting and assessment planning. Diagnostic analyses were performed on the data and CPUE standardization attempted using a GLM approach.

Specific recommendations were made for the attention of the St. Lucia scientists; however, more general recommendations for the attention of all countries submitting data for regional assessment were identified.

Recommendations

- General data collection protocol should be proposed and agreed upon by participating countries
- Recommendations for St Lucia:
    - Default values should not be used
    - Missing values should be retained

Review and adoption of Working Group report, including species/fisheries reports for 2011

The working group report will be adopted by correspondence.

Inter-sessional workplan

- ERAEF
  - Review of SICA report
  - Discussion on appropriate productivity and susceptibility most applicable to the regional pelagic fisheries
- Research on blackfin tuna biology
  - Consider proposals identified by IFREMER and Venezuela on genetics, reproduction and identification of little tunas (MAGDELESA project)
- Paper for ICCAT on blackfin tuna case study
- Data improvement – Grenada data computerization
- Request for US dolphinfish statistics and analyses that were produced by David Die in 2010
- Preparation of information packages for CLME

Any other business

No further issues were raised for discussion.

Adjournment

The meeting was adjourned at 4:30 p.m. on Wednesday 22 June 2011.

B. FISHERIES REPORTS

1.0 Ecological Risk Assessment for the Effects of Fishing (ERAEF) for the Dolphinfish Fishery in the Eastern Caribbean

Lara Puetz

1.1 Overview of ERAEF Experimental Approach

An Ecological Risk Assessment for the Effects of Fishing (ERAEF) framework was developed for the Australian government as a scientific tool to support ecosystem based fisheries management (EBFM). The hierarchical approach is useful for data-deficient fisheries, such as the dolphinfish fishery in the eastern Caribbean, as it facilitates a progression from qualitative (needed in data poor situations) to quantitative analyses with each subsequent level of analysis. It is precautionary because in the absence of data, high risk is associated with fishing activities. ERAEF's overall objective is to determine existing areas of vulnerability for ecosystem components within the fishery and its associated causes, in order to improve the sustainable use of the resource. Several international groups have developed modified versions of ERAEF to assess the potential risk of a fishery in data poor scenarios, such as the ICCAT Ecosystems Working Group, NOAA's National Marine Fisheries Service and the Marine Stewardship Council. In a similar fashion, the Caribbean Regional Fisheries Mechanism (CRFM) could benefit from the use of an EBFM tool such as ERAEF for data poor fisheries, such as the dolphinfish fishery, to promote collaboration in management strategies where such resources are shared.

1.2 Significance for the Caribbean Large Marine Ecosystem Project

One of the main goals of the Caribbean Large Marine Ecosystem (CLME) project is to work towards the sustainable management of shared marine resources within the region. These goals can be obtained through improved regional databases, addressing major issues, causes and actions for the living marine resources and the implementation of management reforms. ERAEF can be used as a tool to assist in the CLME project objectives for the large pelagic dolphinfish fishery exploited by many nations within the western central Atlantic region.

1.3 Objectives and Outputs

The **Scoping** section of the ERAEF framework was discussed and completed in the LPWG during the 2011 CRFM Scientific Meeting. At this stage of the assessment, a profile of the dolphinfish fishery, previously compiled into one comprehensive report, and the units of analysis list for all species, habitats and communities within the fishery were presented to the LPWG for review. The most appropriated management objectives for the dolphinfish fishery were determined by the group which included core objectives (what is trying to be achieved) and operational objectives (how to measure achievement). Finally, the hazards of fishing and external activities within the fishery, leading to the potential harm of the components assessed in the ERAEF analysis, were discussed and reviewed. Completed outputs from the Scoping section will provide a detailed profile of the dolphinfish fishery, including its biological, ecological and environmental components and will inform progressive levels in the ERAEF analysis.

The **Level 1** Scale Intensity and Consequence Analysis (SICA) was commenced and SICA tables for two out of the five ERAEF components were discussed and completed. Goals of the SICA analysis were to determine the most vulnerable element for each component and apply a worst case approach when choosing the most vulnerable sub-component and unit of analysis (species, habitat, communities) associated with each fishing activity. Operational objectives were selected to indicate potential management responses to high risk activities within the fishery. Low consequence activities for target and byproduct/bycatch species were screened out by the working group to determine which hazards associated with the dolphinfish fishery have significant impacts on the two components. The process will help the CRFM direct the development of management solutions with current available data and where to focus future research and resources for the regionally shared stock.

2.0 Data issues highlighted in the assessment of blackfin tuna

Todd Gedamke

2.1 Overview of Available Data

The data submitted by St. Vincent and the Grenadines, St. Lucia, and Trinidad/Tobago were evaluated. For all nations, only records which recorded blackfin tuna were initially submitted. Unfortunately, the filtering of data to only include trips that had positive records for blackfin does not provide the information necessary to evaluate changes in catch rates or inferences on changes in population size. To illustrate this point, consider a fishery where exploitation has significantly reduced population size. Fishers and vessels targeting blackfin, for example, may have been 100% successful 10 years ago and now only 10% of the trips are able to catch their target. By evaluating only the successful (ie. positive trips) the underlying decline in catchability of the species - an indication of declining population size - may be masked by a few fishers that know how or where to exploit the reduced number of individuals in the population. Therefore, to develop an index all available information on catch and effort, regardless of species landed must be available.

The St. Lucia representative was able to provide complete data sets for trips recorded as pelagic trips in order to facilitate a case study on how the methodology should work. It should be stressed here that the results of this exercise should not be treated as a true reflection of the stock. A number of questions about the raw data and how they were collected did not allow a reliable index to be generated. For example, the measure of effort (gear quantity and/or soak time) was filled with a default value of 3 when it was not collected. As a result, it is impossible for the analyst to determine when a true '3' was present and when a default '3' was filled to this data field. Specific to this point the group recommended that default values not be used by data managers and that missing values should be retained. As part of the discussion, the importance of metadata for future CRFM meetings was stressed. In order to ease interpretation in the CRFM forum metadata should comprise at least a few primary components including the definitions of variables included in the data (e.g. units and species codes), explanation of any manipulations from raw form (e.g. use of default values), and any other caveats.

2.2 Overall Recommendations

1. A minimum data collection protocol, including a requirement for the recording of metadata, should be proposed and agreed upon by participating nations. This should comprise data that can reasonably be expected to be collected. Each nation can then add specifics based on the individual characteristics of their fisheries. A list should be developed that starts with the coarsest categories to finest, e.g.:
    1) Catch – Goals: Total catch and catch per trip
    2) Effort –Goals: Total Effort

    The FAO references, http://www.fao.org/docrep/005/X8923E/X8923E00.htm and http://www.fao.org/docrep/W5449E/w5449e00.htm provide information on minimum data collection needs, e.g. see Table 1. below.

2. Factors to be included in a Catch per Unit Effort (CPUE) standardization process:
    Given the lack of available factors to include in a CPUE standardization procedure that were available, the group discussed aspects of fishing which may affect catch rates including:
    1) Spatial information
    2) Fishing area – The group discussed developing a statistical area grid, 1° latitude x 1°longitude, that would cover the entire region. Finer scale information should be attempted to be obtained in each nation.

3) Depth – This information is more critical for reef fisheries, but should be collected for all fisheries.
4) Distance from shore/port/nearest land – This has not proved very meaningful in the US Caribbean, but if clearly defined may serve useful in the pelagic fisheries in particular.
5) Use of fish aggregating device (FADs) – 'Yes/No', 'ID#' for established FADs and codes and descriptors for fishers using/deploying their own FADs
6) Time of fishing – Information to determine the start and end of fishing
7) Lunar cycle – This does not need to be recorded on data sheets as it is easily incorporated into analysis using date of fishing.
8) Bait Type – Condition (e.g. live, dead, lure); species used for live bait
9) Gear Characteristics – Hook type (J, circle), mesh size etc. See FAO catalogue (http://www.fao.org/DOCREP/005/X8923E/X8923E03.htm#ch3.1.1) for details.

Table 1. List of effort measures, in order of priority according to the ability of measure to provide a relationship between fishing effort and fishing mortality).
(From http://www.fao.org/DOCREP/005/X8923E/X8923E03.htm#ch3.1.1)

FIRST	**PRIORITY**	
Fishing Gear	**Effort Measure**	**Definition**
Surrounding nets (purse seines)	Number of sets and	Number of times the gear has been set or shot, and whether or not successfully. This measure is appropriate when school is related to stock abundance or sets are made in a random manner.
	Searching time	This represents time on the grounds, less time spent shooting net and retrieving the catch etc. This measure is complicated by the use of aircraft spotting as well as by the dissemination of information from vessel to vessel. Ideally, it should include the area searched as well. The measure is appropriate when a set is only made when a school has been located.
Fishing with FAD (Fish Attracting Device frequently used with purse seine)	Number of hours or days since last fishing activity	Number of hours or days (duration) in which FAD (Fishing Attracting Device) is left in the water since it was fished last time.
Beach seines	Number of sets	Number of times the gear has been set or shot, and the number of sets in which a catch was made.
Castnet	Number of casts	Number of times the gear has been cast, and whether or not a catch was made.
Boat seines (Danish seine, etc.)	Number of hours fished	Number of hours during which the seine was on the bottom fishing.
Trawls	Number of hours fished	Number of hours during which the trawl was in the water (midwater trawl), or on the bottom (bottom trawl), and fishing.
Boat dredges	Number of hours	Number of hours during which the dredge was on the

	fished	bottom and fishing.
Gillnets (set or drift)	Number of effort units	Length of nets expressed in 100-metre units multiplied by the number of sets made (=accumulated total length in metres of nets used in a given time period divided by 100).
Gillnets (fixed)	Number of effort units	Length of net expressed in 100-metre units and the number of times the net was cleared.
Lift net	Number of hours fished	Number of hours during which the net was in the water, whether or not a catch was made.
Traps (uncovered pound nets)	Number of effort units	Number of days fished and the number of units hauled.
Covered pots and fyke nets	Number of effort units	Number of lifts and the number of units (=total number of units fished in a given time period) and estimated soak time.
Longlines (set or drift)	Numbers of hooks	Number of hooks set and hauled in a given time period.
Pole-and-line	Number of days fished	The number of days fishing (24-hour periods, reckoned from midnight to midnight) including days searching. Similar to purse seine, in that schools are searched for and then fished.
Rod-and-reel (recreational)	Number of line-hours	Number of hours during which the lines were in the water times number of lines used.
Troll	Number of line-days	Total number of line days in the given time period.
Jigs, (hand and mechanical)	Number of line-days	Total number of line days in the given time period.
Other small scale net gears	Number of operations	Number of fishing operations, whether or not a catch was made. These include push net, scoop net, drive-in net etc.
Other small scale stationary gears	Number of hours fished	Number of hours during which the gears were in the water for fishing, whether or not a catch was made. Those gears include guiding barriers, bag net, stow net, portable net, etc.
Harpoons/spears	Number of days fished	The number of days fishing (24-hour periods, reckoned from midnight to midnight) including days during which searching took place without fishing. If more than one spear-fisher operates from a vessel, the numbers of fishers (spears) need to be recorded as well.
SECOND	**PRIORITY**	
Fishing Gear	**Effort Measure**	**Definition**
Boat seines (Danish seine, etc.)	Number of sets made	Number of times the gear has been set or shot, whether or not a catch was made.

Trawls	Number of sets made	Number of times the gear has been set or shot (either in mid-water or to the bottom), whether or not a catch was made
Lift net	Number of hours fished	Number of times the net was set or shot in the water, whether or not a catch was made
All gears	Number of days fished	The number of days (24-hour period, reckoned from midnight to midnight) on which any fishing took place. For those fisheries in which searching is a substantial part of the fishing operation, days in which searching but no fishing took place should be included in "days fished".
THIRD	**PRIORITY**	
Fishing Gear	**Effort Measure**	**Definition**
All gears	Number of days on ground	The number of days (24-hour periods, reckoned from midnight to midnight) in which the vessel was on the fishing ground, and includes in addition to the days fishing and searching also all the other days while the vessel was on the fishing ground.
FOURTH	**PRIORITY**	
Fishing Gear	**Effort Measure**	**Definition**
All gears	Number of days absent from port	The number of days absent from port on any one trip should include the day the fishing craft sailed but not the day of landing. Where it is known that fishing took place on each day of the trip the number of "days absent from port" should include not only the day of departure, but also the day of arrival back in port. Where on any trip a fishing craft visits more than one "fishing area" (as defined for statistical purposes) an appropriate fraction of the total number of days absent from port should be allocated to each "fishing area" in proportion to the number of days spent in each. The total number of trip days should be the sum of the number of days allocated to all of the different "fishing areas" visited.
FIFTH	**PRIORITY**	
Fishing Gear	**Effort Measure**	**Definition**
All gears	Number of trips made	Any voyage during which fishing took place in only one "fishing area" is to be counted as one trip. When in a single trip a craft visits more than one "fishing area" an appropriate fraction of the trips should be apportioned to each "fishing area" in proportion to the number of days spent fishing in each. The total number of trips for the statistical area as a whole should be the same as the sum of trips to each "fishing area".

3.0 Martinique and Guadeloupe fishing fleets targeting Dolphinfish, Flyingfishes and Blackfin tuna

Lionel Reynal[1], Sébastien Demaneche[2] and Olivier Guyader[2] (June 2011)
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3.1 Fishery and Fleet description

During the year 2008 and 2009 in Martinique, 1084 and 1098 boats were registered as commercial fishing boats and in Guadeloupe 878 and 903 respectively. Within the same years, 85% and 82 % (916 & 896) of the vessel fleet were active in Martinique and in Guadeloupe 90% and 86 % (794 & 778) were active. Most of the boats are between 5 to 9 m total length. The 7 to 9 m boats are more frequent in Martinique (figure 1). During the last decade, the number of 7 to 9m boats increased in Guadeloupe while the number of 5 to 7 m boats decreased (figure. 2). The average length of the boats is similar between the two French Antilles, but the engine average power is higher in Guadeloupe (139 kW *vs* 80). The total power of the fleets had increased steadily from 56,788 to 87,420 kW in Martinique between 1993 and 2009 and at the same time, from 84,240 to 125,874 kW in Guadeloupe. The average age of the boats are 16 years in Martinique and 11 years in Guadeloupe.

Dolphinfish, flyingfish and blackfin tuna are mainly targeted using the following:

- High sea hand lines and trolling lines for large pelagic fishes,
- Trolling lines and drifting vertical lines around FADs for large pelagic fishes,
- High sea drifting nets for flyingfish (Martinique only),
- Nets for flyingfish during High sea lines for large pelagic fishes (Martinique only).

Flyingfish are not targeted by the commercial fishing boats of Guadeloupe. This is practiced mainly by high sea fleets. Related to the typology made by IFREMER, 10 different fleets are distinguished (table 1) totalling 464 boats in Guadeloupe and 435 in Martinique (2008).

The boats of these high sea fleets share their activities between high sea and the insular shelves. An example of the seasonality of the different activities is given for Martinique in 2008 (figure 3). The seasonal activity of the high sea hand and trolling lines which are targeting mostly dolphinfish between December to June, impacts others activities which are higher from July to November. The total number of trips per year on the insular shelves is higher than at high sea (figure 4). The drifting nets for flyingfish are used on the west coast of Martinique inside the 24 NM limit. FADs are mainly exploited inside the 24 NM while high sea hand and trolling lines are fishing outside the 24 NM (figures 5 & 6).

Fishing around Moored Fish Aggregating Devices (FADs) took place in Martinique and Guadeloupe during the 90's and seems to have changed the activity and the seasonality of the high sea fishing. The data from enquiries made in 1979 and 1989 show a high proportion of boats practising high sea lines during the first half of the year and a sharp decline in the second half of the year. In 2006, this seasonality is less definite. The high sea boats share their activities between high sea lines and FADs. Fishing is practised all year long; as a result some of the high sea boats stay offshore between June to December (figure 7).

3.2 Statistics and Sampling

A Fisheries Information System (FIS) conceived by IFREMER has been implementing in Guadeloupe and Martinique since the beginning of 2010 after a pilot project was ran in 2008 in Guadeloupe and May

2008 to December 2009 in Martinique. The FIS is a permanent, operational and multidisciplinary national network (figure 8) for the observation of marine resources and their associated uses.

The methods used are the following:

- *Phone investigation*: stratified sampling plan based on a simple stratified random sampling of the vessel each week to reconstitute trip and inactivity on 7 days. Stratification (25 stratums) made out of length, gradient and zone of fishing of the vessel. In Martinique, 75 interviews are made per week and 60 in Guadeloupe.
- *Sampling at landing points*: sampling strategy of harbours with at least 10 vessels between Monday to Friday.

The pilot studies give first preliminary figures on the extrapolated landings of these islands but this data has to be validated. The scattering of the landing points around Guadeloupe and Martinique (more than 100 in each island) makes the monitoring of the fishing activities difficult. The use of two methods to estimate the number of trips gave results up to 2 times less than those obtained in Martinique by a previous study 20 years ago (Gobert, 1989). A field survey has been launched in Martinique in order to improve this issue.

The annual estimates of the landings are presented in table 2 for Martinique (2009 & 2010) and table 3 for Guadeloupe (2008) with their confidence intervals. The CPUE are given in the same tables. For Martinique some of small blackfin tunas (2 kg or less) are in a category called "non identified *Thunnini"*. In this unidentified *Thunnini* the proportion of blackfin tuna is unknown. The weights of the fish are recorded as round whole for the flyingfish and *Thunnini* and gutted for the dolphinfish and blackfin tuna.
Estimates of catch rates per trip obtained during stratified random surveys in 2008-2009 in Guadeloupe and Martinique were used to reconstruct the total annual catch by assuming that these catch rates represent average catch rates for the fishery through the entire historic period. Annual catch was calculated as the product of the catch rate and the number of boats per year. Annual catch estimates for 2008, the period for which there is more reliable data, range from 393 to 561 t (metric tons) per year, which represents an estimate of 474 t (metric tons) for dolphinfish in Guadeloupe and 12 to 17 t for blackfin tuna (estimate 14 t).

In Martinique, for 2009 estimates range from 23 to 64 t (estimate 40 t) for dolphinfish and from 9 to 29 t (estimate 18 t) for blackfin tuna.

The final estimates of historical harvest for both islands therefore start from a small catch rate around FADs of 3 tons of dolphinfish and 1 ton of blackfin tuna in 1985. made in Martinique to 377 t of dolphinfish and 20 t of blackfin tuna for both islands in 1997, to the present estimate of between 416 to 625 t of dolphinfish and 21 to 46 for blackfin tuna in 2008 (tables 4 & 5).

For other gears, the estimate of historical catches cannot be determine because of the lack of information on the evolution of the number of boats and the change in the fishery as there was significant increases of engine power and the achievement of FADs fishing.

In 1987, the estimates of annual landings in Martinique done by Gobert (1989) were up to 370.4 t for flyingfish and 247.8 t for dolphinfish. The high sea lines number of trips was estimate at 24,477 and the catch per trip for dolphinfish at 10.12 kg. Several assumptions could explain the high difference of CPUE value between 1987 and 2009 which includes increasing engine power which allows the boats to search in wider area and differences in abundances however no assertion can be given. As a consequence, it seems hazardous to try to build historical data series for high sea lines.

The monthly catches per trip show peaks of CPUE in March-April for dolphinfish and flyingfish and between June and September for blackfin tuna. The curve of the unidentified *Thunnini* CPUE has several peaks which suggest a mixture of species with different seasonality (tables 6 & 7).

Limited data is available on length frequencies in Martinique (table 6) for dolphinfish in 1986 & 1987 (figure 8) and for blackfin tuna in 1986 & 1987 (figure 9) and 2008 & 2009 (figure 10). The blackfin tuna length frequencies indicate two predominant modal classes, one less than 30 cm fork length and the other between 45 and 60 cm. According to Doray *et al.* (2004), young blackfin tuna probably leave the vicinity of Martinique to undergo a trophic migration at 7 to 8 month-old, and thereafter comes to breed in the Lesser Antilles area. The lengths of dolphinfish are between 24 and 128 cm (figure 11).

3.3. Research

Research projects on FADs sustainable development were conduct in Martinique by IFREMER. A Lesser Antilles project named MAGDELESA was proposed to start in October 2011. An ongoing project is conducting a diagnostic in Martinique and Guadeloupe of the contamination of the fishing faun by chemical products and especially by the chlordecone: a pesticide used in banana plantations. Other organisms are working mostly on coral with the objective to protect this ecosystem and the associated resources. The implementation of the FIS will bring the necessary information needed to conduct research on biodiversity of the marine faun of the French West Indies.

3.4. Legislation and Management Regulations

There are no special legislation and management regulations for commercial fishing of dolphinfish, blackfin tuna and flyingfish. In Guadeloupe, recreational fishing is limited to 3 fish per trip and person on board. Regulation measures on FADs have been taken in Martinique and Guadeloupe. Limit of total power and gross tonnage is separately imposed for the Commercial fleets of Guadeloupe and Martinique.

Literature cited

Doray M., B. Stéquert and M. Taquet, 2004. Age and growth of blackfin tuna (*Thunnus atlanticus*) caught under moored fish aggregating devices around Martinique Island. Aquat. Living Resour. 17, 13-18.

Gobert B., 1989. Effort de pêche et production des pêcheries artisanales martiniquaises. Document scientifique n° 22, 95 p.

Figures and Tables

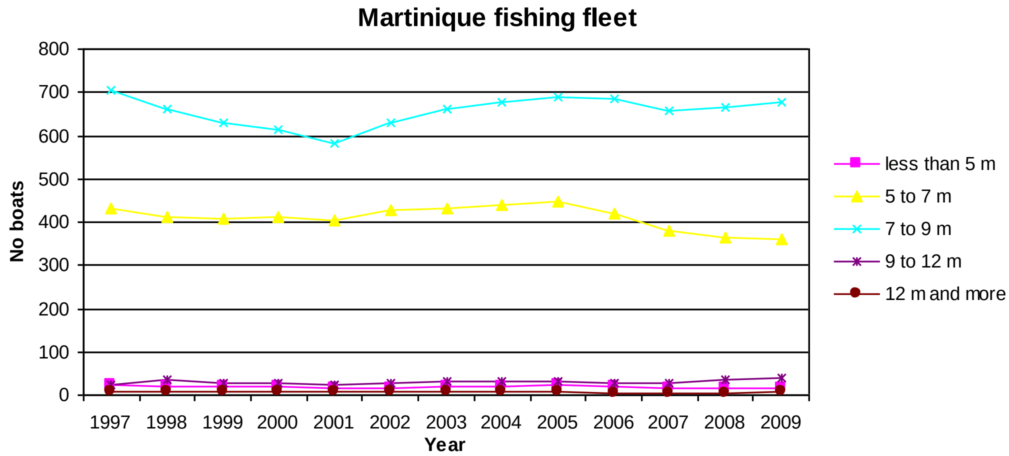


Figure 1. Length frequencies of the fishing fleet of Martinique (1997 to 2009)

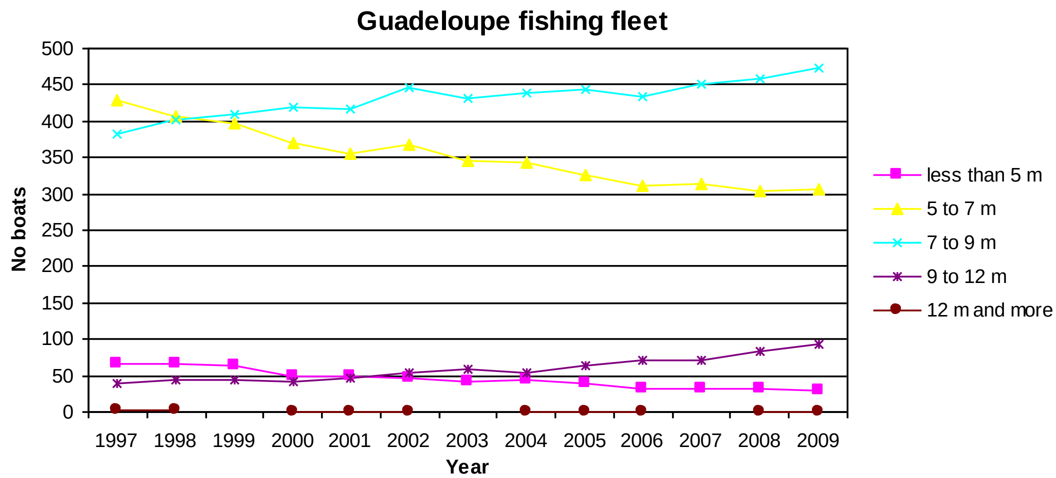


Figure 2. Length frequencies of the fishing fleet of Guadeloupe (1997 to 2009)

Fleets / Number of boats (2008)	Guadeloupe	Martinique
FADs	63	85
FADs - Traps	73	87
FADs - Nets	25	39
FADs - others lines	37	16
FADs - Polyvalent fixed gears	104	61
High sea hand and Trolling lines	12	17
High sea hand and Trolling lines - Traps	41	77
High sea hand and Trolling lines - Nets	24	12
High sea hand and Trolling lines - others lines	13	3
High sea hand and Trolling lines -Polyvalent fixed gears	72	38
Total	**464**	**435**

Table 1. High sea fishing fleets of Guadeloupe and Martinique (2008)

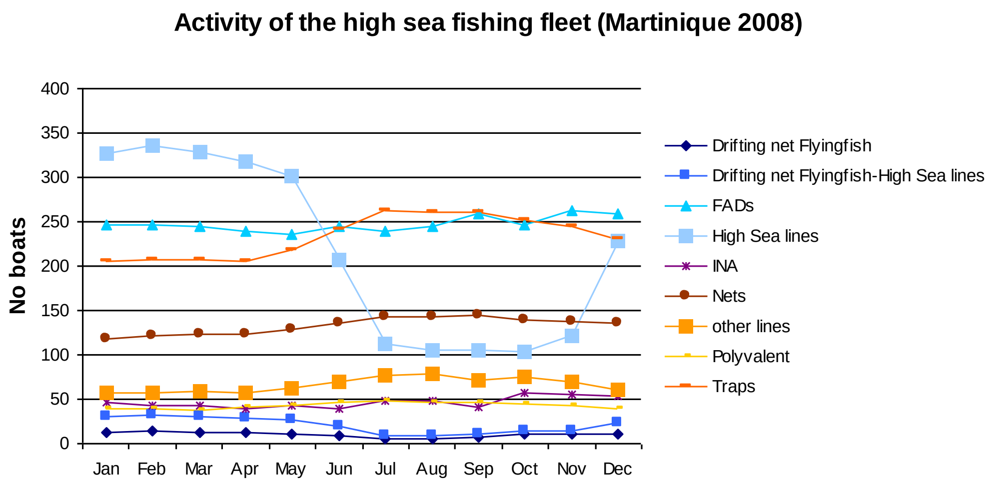


Figure 3. Seasonality of the high fishing fleet of Martinique – number of boats per month and metier (2008)

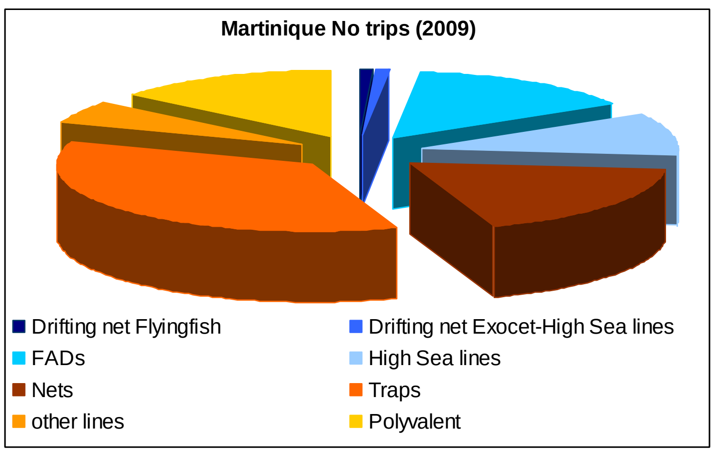


Figure 4. Number of trips per metier of the high sea fishing fleet of Martinique (2009)

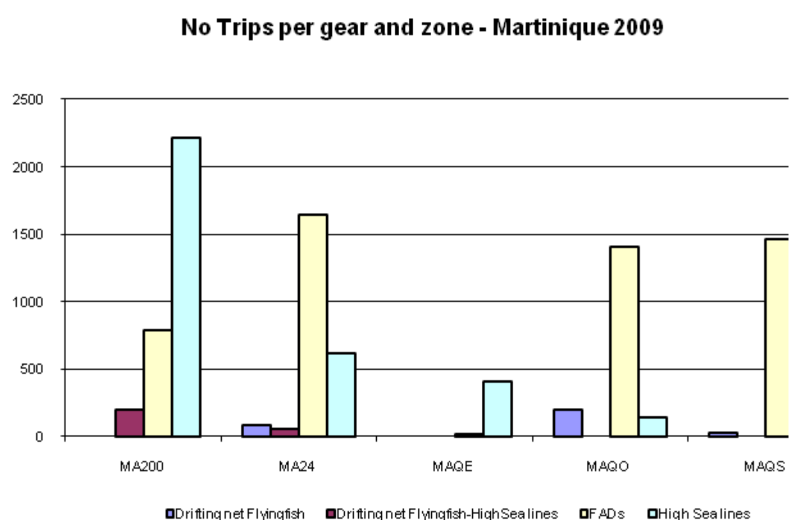


Figure 5. Number of trips per zone of the high sea fishing fleet of Martinique

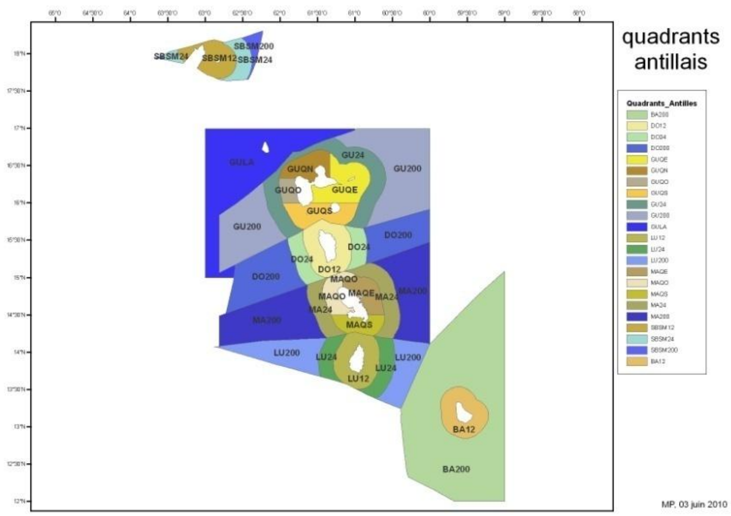


Figure 6. Map of the zone used by the FIS of Ifremer

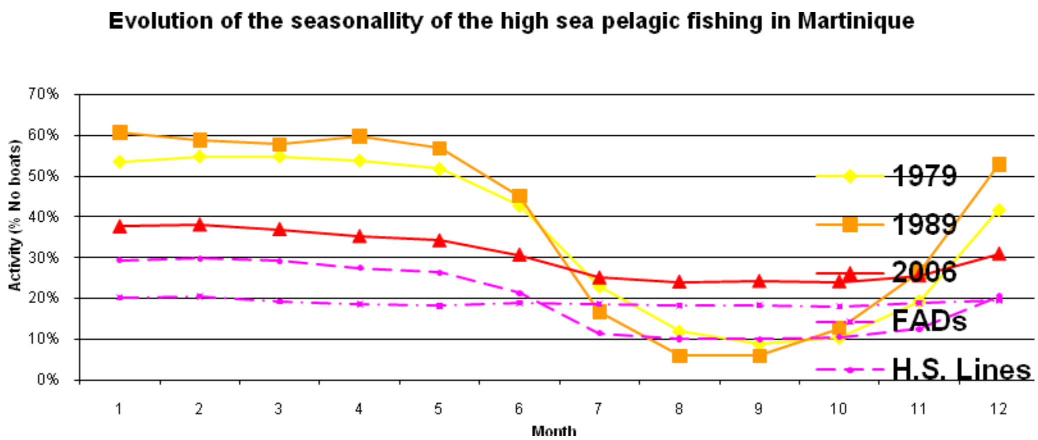


Figure 7. Evolution of the seasonality of the high sea pelagic fishing in Martinique

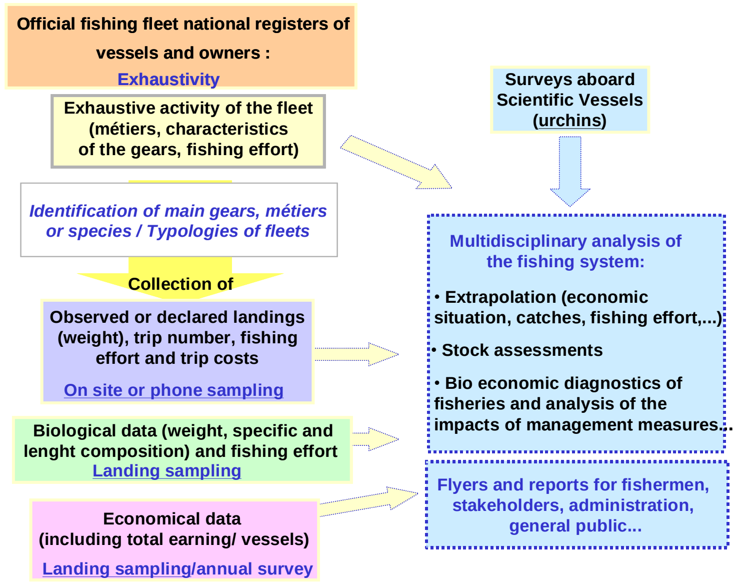


Figure 8. Organisation of the FIS of Ifremer

Metier	No trips Martinique	Martinique 2009 - Landings (kg) Flyingfish	Dolphinfish	Blackfin tuna	Small thunnini (<+2 kg)	Martinique 2009 - CPUE (kg) Flyingfishe	Dolphinfishe	Blackfin tuna	Small thunnini (<+2 kg)
Drifting net Flyingfish	2 571	34 199			170	13.30			0.07
FADs	6 088	612	40 406	17 571	49 773	0.10	6.64	2.89	8.18
High Sea lines (+Drifting nets)	6 388	4 434	192 806	9 442	13 459	0.69	30.18	1.48	2.11
other lines	595		472	242			0.79	0.41	
Total estimate		**39 577**	**234 689**	**28 913**	**69 823**				
Low		*14 407*	*144 417*	*13 939*	*34 251*				
High		*81 445*	*351 159*	*50 801*	*126 930*				

(a)

Metier	No trips Martinique	Martinique 2010 - Landings (kg) Flyingfish	Dolphinfish	Blackfin tuna	Small thunnini (<+2 kg)	Martinique 2010 - CPUE (kg) Flyingfish	Dolphinfish	Blackfin tuna	Small thunnini (<+2 kg)
Drifting net Flyingfish	1 816	67 607				37.23			
FADs	6 120	308	12 334	9 066	46 253	0.05	2.02	1.48	7.56
High Sea lines (+Drifting nets)	4 709	3 786	124 268	5 794	19 525	0.80	26.39	1.23	4.15
other lines	304			881	551			2.90	1.81
Total estimate		**84 674**	**153 136**	**17 215**	**66 140**				
Low		*44 248*	*104 207*	*7 892*	*49 504*				
High		*138 177*	*217 540*	*29 842*	*85 475*				

(b)

Table 2. Number of trips, catches and CPUE per gear used to target the fishes for Martinique 2009 (a) and 2010 (b) – Data to be validated.

Metier	No trips Guadeloupe	Guadeloupe 2008 - Landings (kg) Flyingfish	Dolphinfish	Blackfin tuna	Guadeloupe 2008 - CPUE (kg) Flyingfish	Dolphinfish	Blackfin tuna
Decked boat	559		119 752			214.23	
FADs	14 110	88	474 231	14 030	0.01	33.61	0.99
High Sea lines (+Drifting nets)	8 055	248	553 711	1 177	0.03	68.74	0.15
Total estimate		**336**	**1 147 694**	**15 207**			
Low		*1 209*	*945 883*	*12 567*			
High		*2 408*	*1 397 258*	*18 016*			

Table 3. Number of trips, catches and CPUE per gear used to target the fishes for Guadeloupe 2008 – Data to be validated

Year	Low Dolphinfish Landings	High Dolphinfish Landings	Dolphinfish Landings estimates	Low Blackfin tuna Landings	High Blackfin tuna Landings	Blackfin tuna Landings estimates
1985	1	4	3	1	2	1
1986	1	4	3	1	2	1
1987	5	13	8	2	6	4
1988	5	13	8	2	6	4
1989	5	13	8	2	6	4
1990	5	15	9	2	7	4
1991	6	17	10	2	8	5
1992	6	17	10	2	8	5
1993	7	18	12	3	8	5
1994	7	20	13	3	9	5
1995	7	20	13	3	9	5
1996	9	24	15	3	11	7
1997	12	33	21	5	15	9
1998	15	41	26	6	19	11
1999	16	46	29	7	21	13
2000	18	50	31	7	23	14
2001	20	55	35	8	25	15
2002	21	59	37	8	27	16
2003	21	59	37	8	27	16
2004	22	61	39	9	28	17
2005	24	67	42	9	31	18
2006	24	67	42	9	31	18
2007	23	66	41	9	30	18
2008	23	64	40	9	29	18
2009	**23**	**64**	**40**	**9**	**29**	**18**

Table 4. Estimates of historical catch (t) of FADs fishing for Dolphinfish and Blackfin tuna in Martinique

year	Low Dolphinfish Landings	High Dolphinfish Landings	Dolphinfish Landings estimates	Low Blackfin tuna Landings	High Blackfin tuna Landings	Blackfin tuna Landings estimates
1985	0	0	0	0	0	0
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	20	28	24	1	1	1
1990	49	70	59	1	2	2
1991	59	84	71	2	2	2
1992	89	126	107	3	4	3
1993	187	267	226	6	8	7
1994	197	281	238	6	8	7
1995	207	295	249	6	9	7
1996	275	393	333	8	12	10
1997	295	421	356	9	12	11
1998	305	436	368	9	13	11
1999	334	478	404	10	14	12
2000	354	506	428	10	15	13
2001	374	534	451	11	16	13
2002	374	534	451	11	16	13
2003	374	534	451	11	16	13
2004	374	534	451	11	16	13
2005	374	534	451	11	16	13
2006	374	534	451	11	16	13
2007	364	519	439	11	15	13
2008	**393**	**561**	**474**	**12**	**17**	**14**

Table 5. Estimates of historical catch (t) of FADs fishing for Dolphinfish and Blackfin tuna in Guadeloupe

Year	Spieces	Gear	Jan	Feb	Mar	Apr	May	Jun	Jul	Agu	Sep	Oct	Nov	Dec
2009	Dolphinfish	FADs	5.82	18.50	6.85	16.21			5.40	3.14	1.71	1.17	0.51	2.46
2009	Dolphinfish	High Sea lines (+Drifting nets)	9.53	23.20	56.20	38.07	35.23	19.94	7.63		0.60		7.86	17.50
2009	Blackfin tuna	FADs	0.88		1.71	1.67	0.77	3.00	9.50	4.29	6.97	0.81	1.26	
2009	Blackfin tuna	High Sea lines (+Drifting nets)	3.82	0.00	0.93	0.65	1.92	1.55	6.73	13.40	2.30		6.43	
2009	Thunnini	FADs	1.35	3.64	4.52	3.43	4.00	4.00	0.60	19.71	7.83	2.47	6.89	12.83
2009	Thunnini	High Sea lines (+Drifting nets)	3.82		0.29	2.95		0.09	2.97	10.20	8.00	13.67	1.79	4.00
2009	Flyingfish	Drifting net Flyingfish	13.33	1.00	35.69		25.70	1.38		15.00				
2009	Flyingfish	High Sea lines (+Drifting nets)				0.18	4.46	3.41						7.50
2010	Dolphinfish	FADs	0.42	4.58		2.22	3.63	3.86	1.68		1.50	0.22	1.32	2.67
2010	Dolphinfish	High Sea lines (+Drifting nets)	29.12	15.62	16.60	56.25	30.31	3.17	16.50					4.57
2010	Blackfin tuna	FADs		3.58		1.11	1.95	0.74	0.89	2.44	1.07	1.93		0.24
2010	Blackfin tuna	High Sea lines (+Drifting nets)	5.38		2.09		0.37							
2010	Thunnini	FADs	8.05	3.26	9.23	9.67	11.08	3.75	6.31	7.00	5.05	12.42	11.36	4.89
2010	Thunnini	High Sea lines (+Drifting nets)	4.49	9.45	2.13	0.42	0.89	5.56	0.83	3.00		35.00		4.86
2010	Flyingfish	Drifting net Flyingfish	63.50	16.89	83.70	8.67	23.00	6.25	0.10			56.96	4.50	63.53
2010	Flyingfish	High Sea lines (+Drifting nets)	0.51	0.01	1.59	3.33	2.69							

Table 6. Estimates of average catch per trip (kg) for Dolphinfish, Blackfin tuna, and flyingfish per main gear – Martinique 2009 & 2010

Year	Gear	Jan	Feb	Mar	Apr	May	Jun	Jul	Agu	Sep	Oct	Nov	Dec
2009	DCP	661	423	568	505	207	29	331	483	599	803	804	672
2009	Drifting net Flyingfish	281		951	269	209	138	117	58	240			308
2009	High Sea lines (+Drifting nets)	786	1338	1277	1400	433	304	367	110	92	155	85	42
2010	DCP	268	321	200	385	320	785	691	682	510	756	554	649
2010	Drifting net Flyingfish	164	207	140	210	80	139	31	36	36	181	338	252
2010	High Sea lines (+Drifting nets)	521	754	1138	438	1136	314	92	18	0	30	15	252

Table 7. Estimates of the number of trips per month for the main gears witch target Dolphinfish, Blackfin tuna and flyingfish – Martinique 2009 & 2010

Type of Length	FL (cm)					TL (cm)		
Year	2008			2009		1986	1987	
Gear	FADs	H.S. Lines	Other lines	FADs	H.S. Lines	H.S. Lines	H.S. Lines	Deep trolling Lines
Dolphinfish	53	60	0	0	0	286	597	9
Blackfin tuna	190	19	11	46	11	186	287	216

Table 8. Number of length frequencies data available in Martinique for Dolphinfish and Blackfin tuna

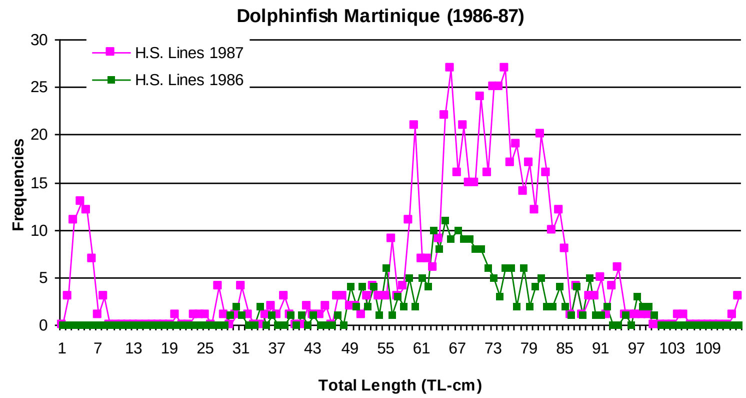


Figure 8. Total length (TL – cm) frequencies of Dolphinfish in 1986 and 1987 in Martinique

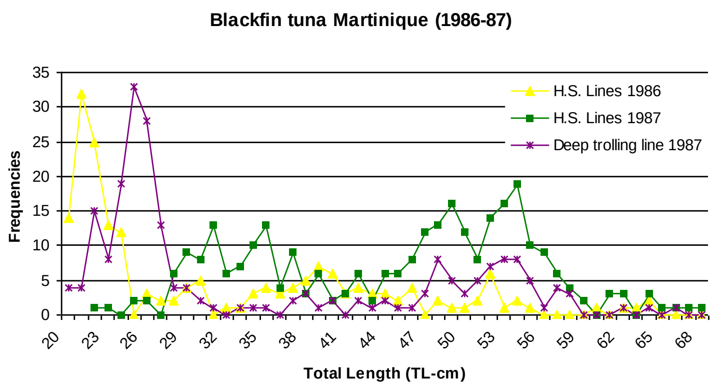


Figure 9. Total length (TL – cm) frequencies of Blackfin tuna in Martinique (1986-87)

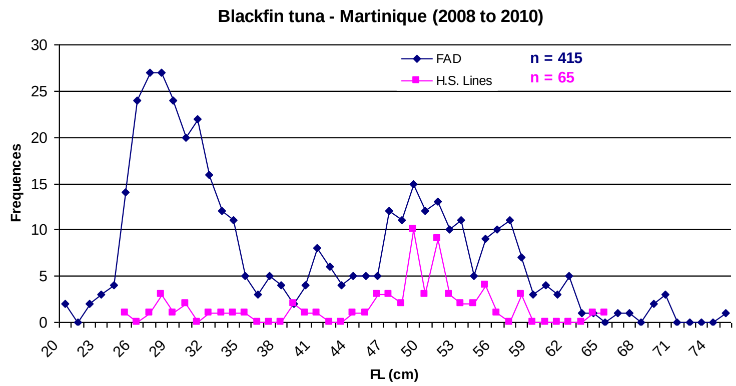


Figure 10. Fork length (FL – cm) frequencies of Blackfin tuna in Martinique (2008-10)

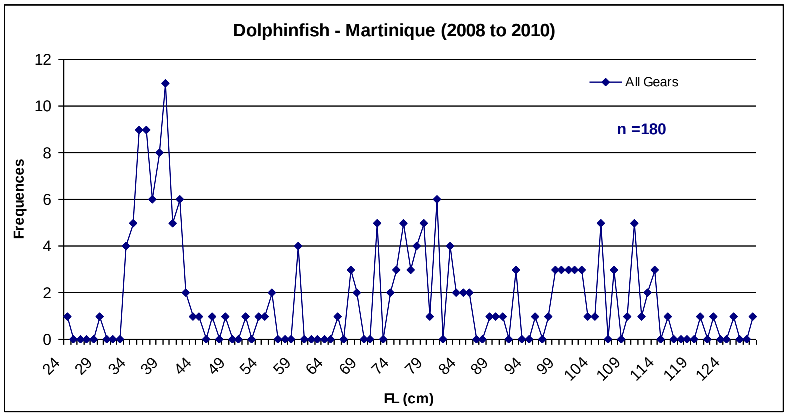


Figure 11. Fork length (FL – cm) frequencies of Dolphinfish in Martinique (2008-2010)

4.0 Blackfin tuna catch, catch rates, and size structure from Venezuelan fisheries

Freddy Arocha, Alexander Bárrios, Jésus Marcano, and Xiomara Gutiérrez

Blackfin tuna is commonly caught by industrial and artisanal Venezuelan fleets throughout the Caribbean Sea and adjacent waters. The Venezuelan purse seine fleet that operates in the Caribbean Sea consists of 10 vessels, mostly with a capacity of 600 t; while the baitboat fleet consists of about 8 vessels with a capacity that ranges between 50 and 250 t. This fleet operates most of the time in conjunction with the purse seine fleet. The artisanal fleets that fish for blackfin tuna are the offshore small scale fleet that uses pelagic longline gear, and the coastal artisanal drift-gillnet fishery.

As per recommendation in the CRFM Blackfin tuna report, the total historical catch information available for blackfin tuna was revised. Upon the revision it was concluded by the Venezuelan tuna working group that the most reliable data on blackfin tuna catches were those available from TASK II information in the ICCAT database, as it corresponded to accurate port sampling and monitoring of >80% of the logbook data controlled by trained officials. Additional catch information from the artisanal fleets was included to account for the total catch of blackfin tuna from Venezuela. The highest catches were observed between 1998 and 2002, when in 2001 reached its peak of over 1700 t (Figure 1), since then the catch has remained at around 300 t, with the exception of 2004 and 2007 when catches increased to about 700 t. Although, the main blackfin tuna catch come from the Venezuelan industrial surface fleets, in the last year of the series the artisanal drift-gillnet fleet account for a substantial increase with respect to previous years.

Blackfin tuna caught by the Venezuelan fishery showed a strong seasonal positive signal towards the end of the year in two of the fleets (purse seine and offshore small scale longline). While the artisanal coastal drift-gillnet showed a seasonal increase towards the beginning of the year (Figure 2), possibly indicating an offshore–inshore movement between the end and the beginning of the year.

Standardization of catch rates were attempted for the industrial surface fleets using general linear model (GLM) techniques. The relative indices of abundance for blackfin tuna were estimated by Generalized Linear Modeling approach assuming a lognormal model distribution. However, only relative indices of abundance of the baitboat fleet were adequately standardized as indicated by the diagnostic plots (Figure 3). However, the model utilized was not appropriate for standardizing the relative indices of abundance from the purse seine fleet; no attempts were made to explore other options during the meeting but will be carried out in the near future. The standardized relative indices of abundance of blackfin tuna from the baitboat fishery show an uneven sustained declining trend beginning in 1997 (Figure 4 a), showing a minor recovery at the end of the time series. The nominal blackfin tuna catch rates from the purse seine fleet appear to be around or below 250 t/effective fishing days (EFF) during most of the time period, with three noticeable peaks in 1990, 1992-93, and 2001-02, of 1400 t/EFF, ~1000 t/EFF, and ~900 t/EFF, respectively (Figure 4 b). The reason for the decreased trend is unknown and requires further in depth analysis to be undertaken in the future.

Annual and seasonal size structure was analyzed for both surface fisheries. The average annual size structure from the purse seine fleet did not vary throughout the time series, in contrast to the size structure from the baitboat fleet where average sizes were larger in some years (Figure 5 a). Similarly, the seasonal size structure from the baitboat fleet showed a trend in which the average of large fish increased from April to July (Figure 5b), in contrast to the seasonal average size structure from the purse seine fleet where no trends were observed.

The temporal and spatial distribution of the combined size structure of blackfin tuna from both industrial surface fleets were presented by separating adult and mature fish (> 50 cm FL) from those that were not

(Figure 6). The sampled catch appears to be dominated by adult mature fish throughout the season over all the fishing area, with the exception of the second quarter where adult mature fish seem to be more common. However, during the first quarter, non-mature fish (<50 cm FL) appear to be important in catches in the eastern section of the fishing area, and it appears the within this area an important proportion of the fish in the sampled catch are non-mature fish.

The information from blackfin tuna catches from the offshore small scale longline fleet and the coastal artisanal drift-gillnet fishery is very limited. Despite the recent increase in catch from one of these fleets, the information if any is mostly limited to catch statistics. One of the main reasons is that blackfin tuna from these fleets is mostly reported as 'albacora' and often is misidentified in official statistics as *Thunnus alalunga*, *T. albacares* or placed under the category of 'other tunas' or 'small tunas'. However, the Instituto Oceanografico of the Universidad de Oriente in Cumaná has started an enhanced monitoring program of the offshore small scale longline fleet that will contribute to increase our knowledge of blackfin tuna captured by this fleet.

Figures

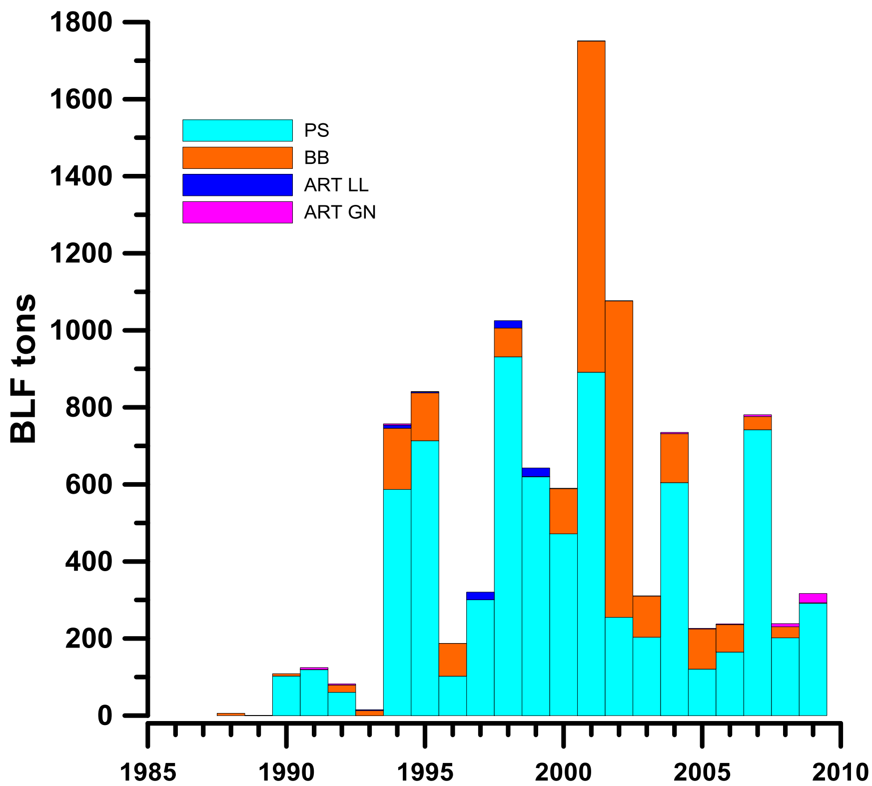
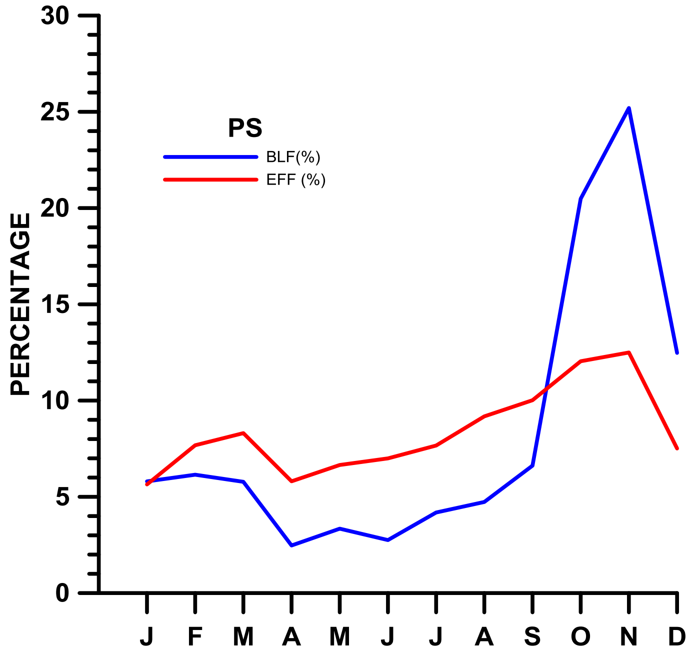
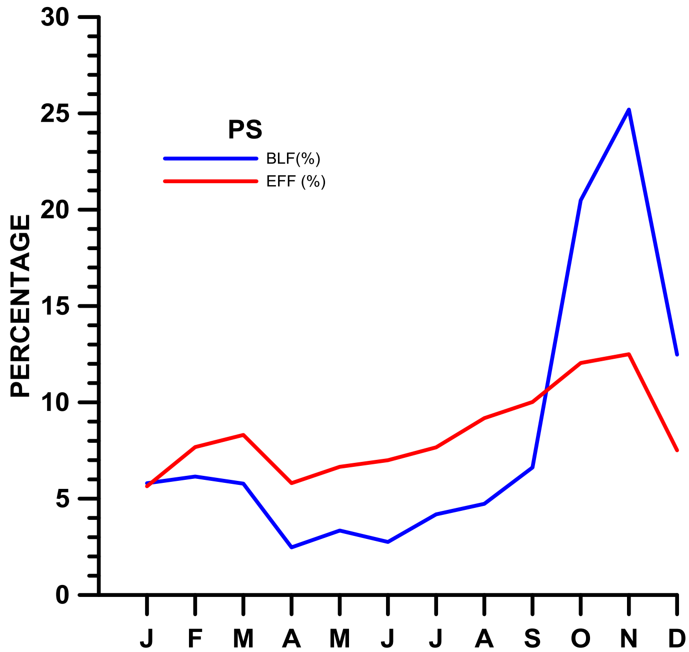
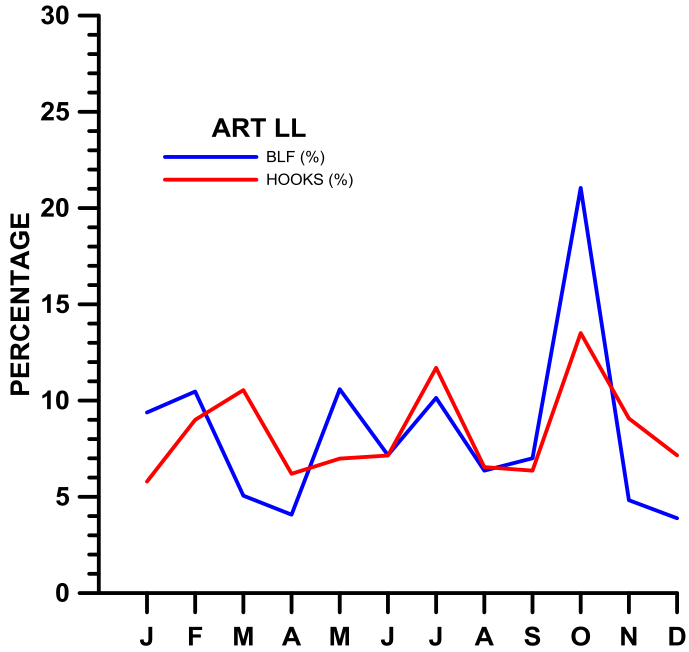


Figure 1. Blackfin tuna (BLF) total catches by gear from Venezuela between 1988 and 2009.


PS
BLF(%)
EFF (%)
PERCENTAGE
30
25
20
15
10
5
0
J F M A M J J A S O N D


PS
BLF(%)
EFF (%)
PERCENTAGE
30
25
20
15
10
5
0
J F M A M J J A S O N D



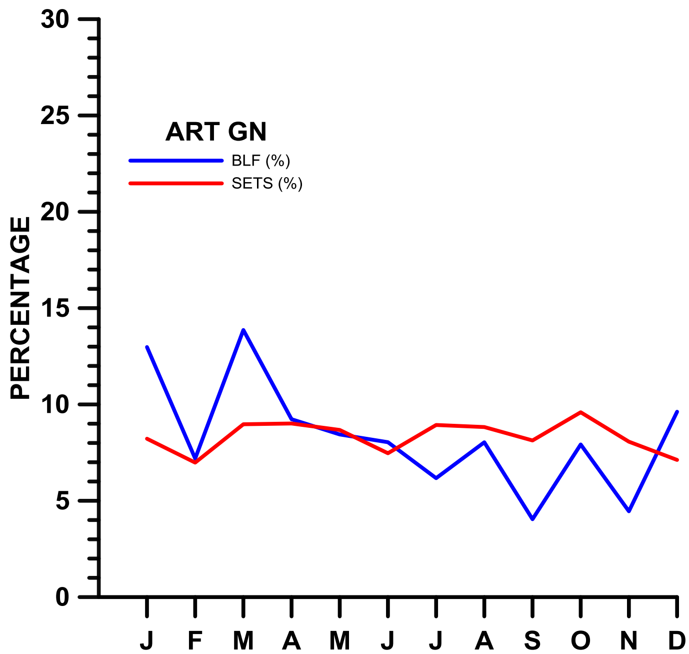
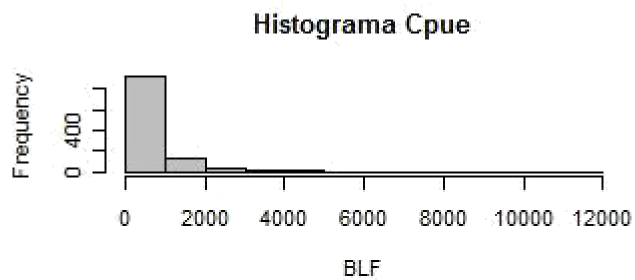
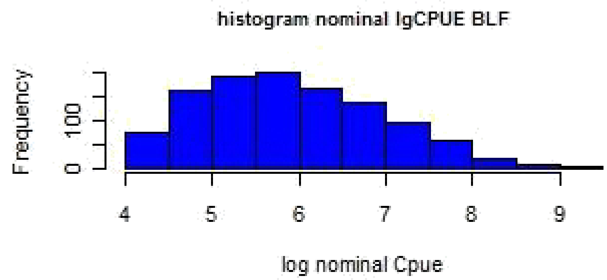


Figure 2. Cumulative monthly blackfin tuna catches and effort from the Venezuelan purse seine (PS), baitboat (BB), artisanal longline (ART LL), and artisanal drift-gillnet fleets (ART GN).


Histograma Cpue
Frequency
0
400
0
2000
4000
6000
8000
10000
12000
BLF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Frequency
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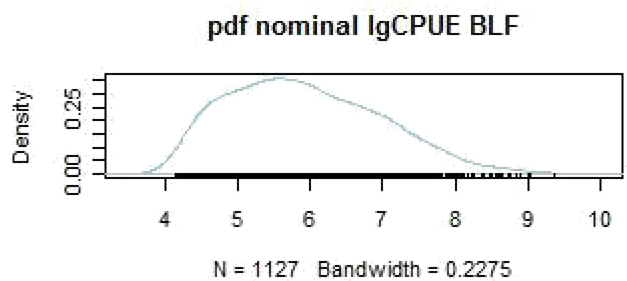
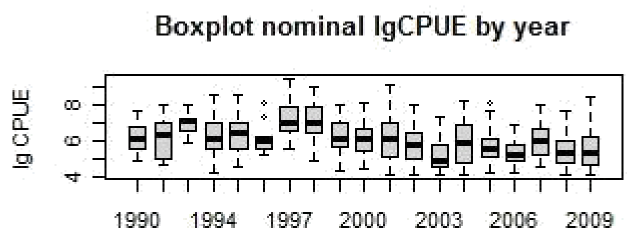
100
4
5
6
7
8
9
log nominal Cpue


pdf nominal lgCPUE BLF
Density
0.00
0.25
4
5
6
7
8
9
10
N = 1127 Bandwidth = 0.2275


Boxplot nominal lgCPUE by year
lg CPUE
4
6
8
1990
1994
1997
2000
2003
2006
2009

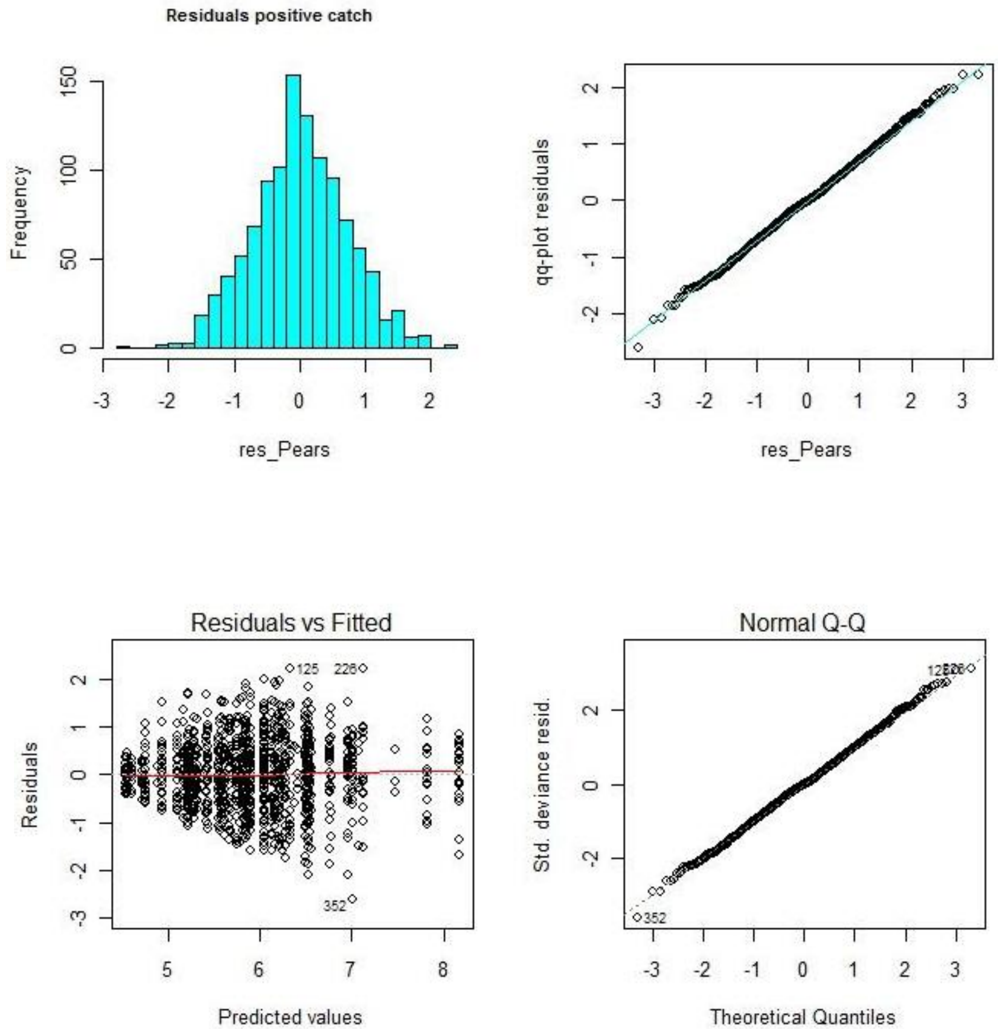


Figure 3. Exploratory plots for lgCPUE of blackfin tuna (right panel) and diagnostic plots of residuals from the GLM of lgCPUE (left panel).

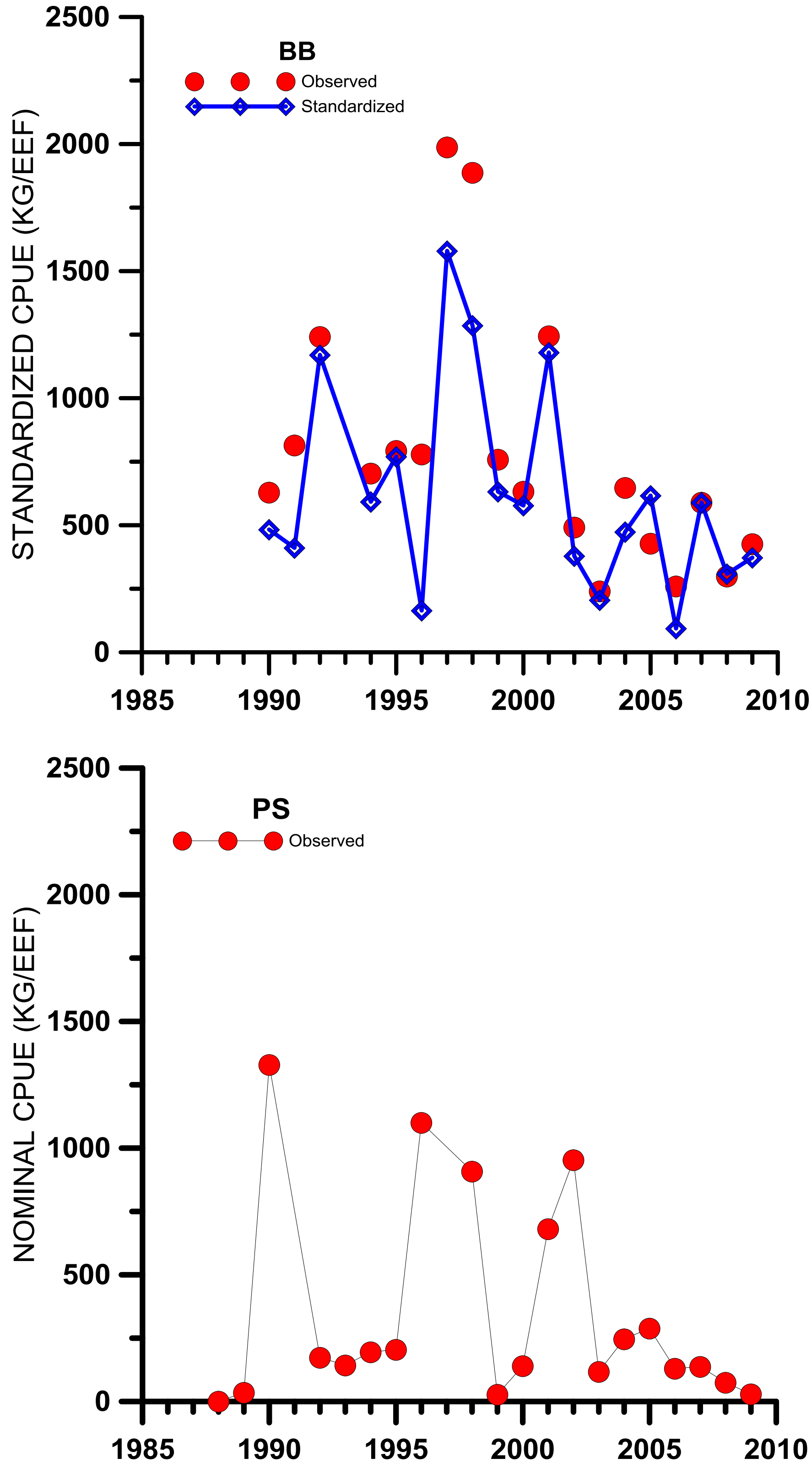
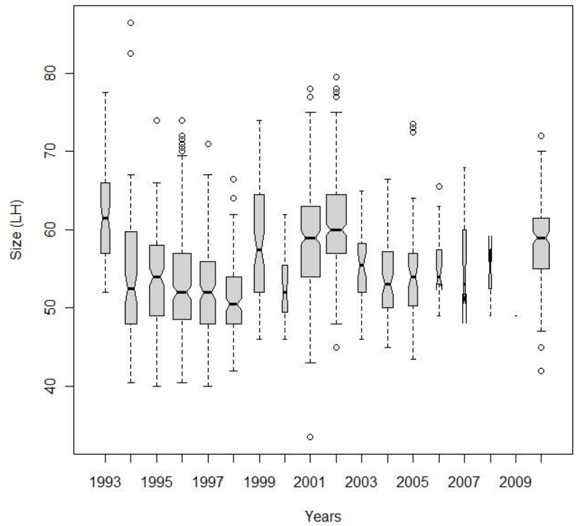
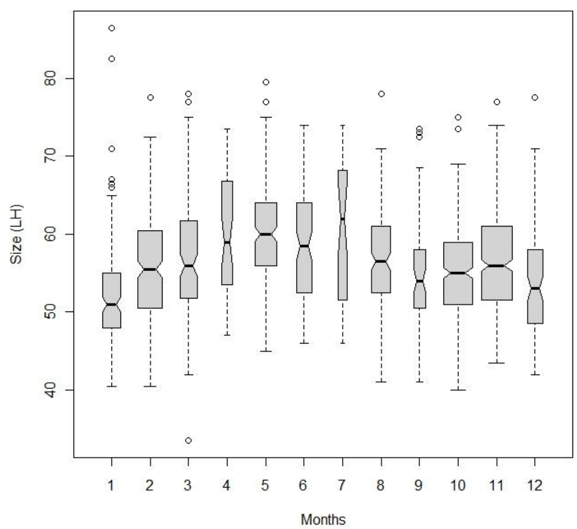


Figure 4. Standardized indices of relative abundance of blackfin tuna from the baitboat (BB) fleet, and nominal catch rates of blackfin tuna from the purse seine (PS) fleet.

BB

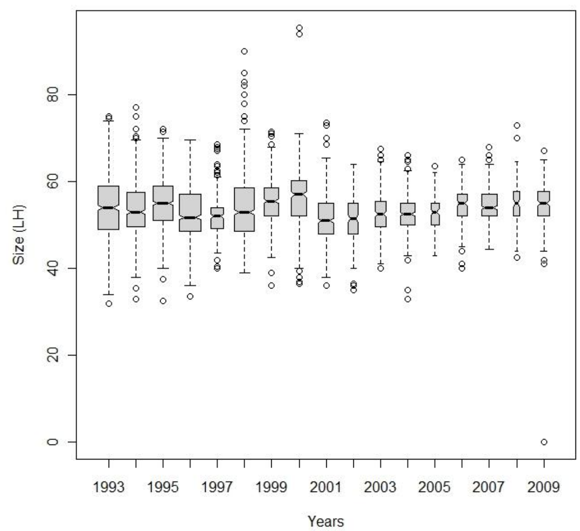


Size (LH)
80
70
60
50
40
1993
1995
1997
1999
2001
2003
2005
2007
2009
Years



Size (LH)
80
70
60
50
40
1
2
3
4
5
6
7
8
9
10
11
12
Months

PS



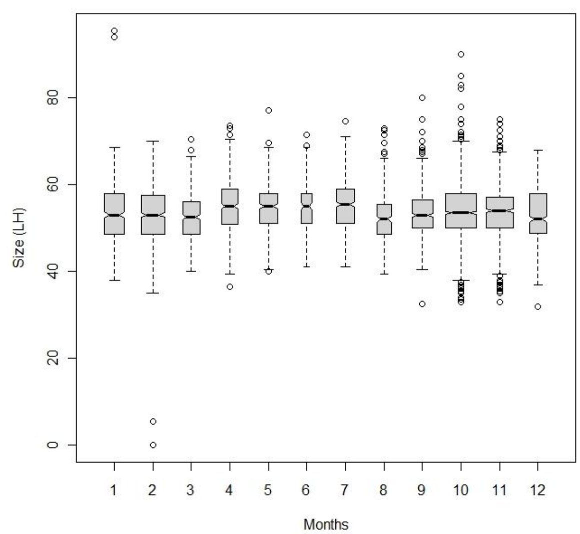
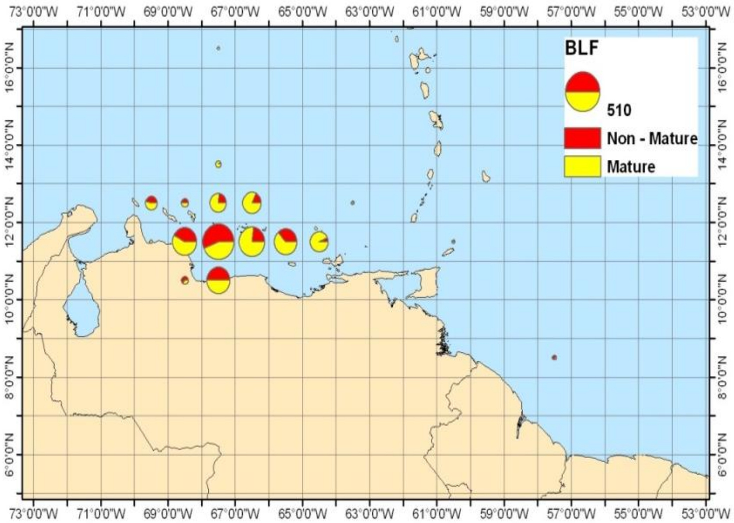
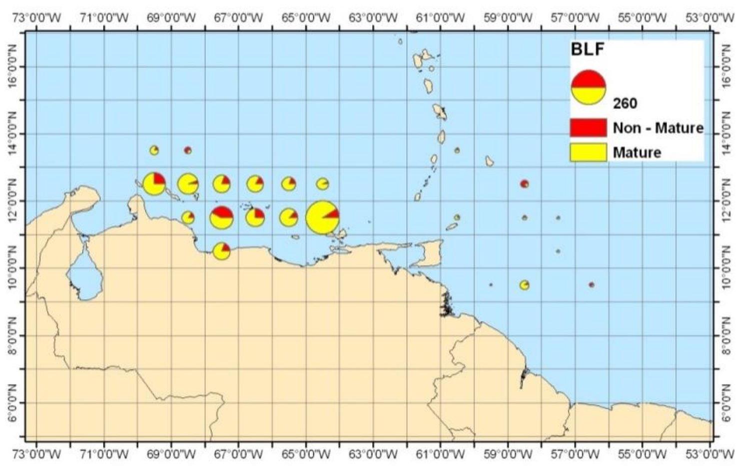


Figure 5. Annual and cumulative monthly size structure of sampled catch of blackfin tuna from the Venezuelan industrial surface fleets, baitboat (BB) and purse seine (PS).

Q1



Q2



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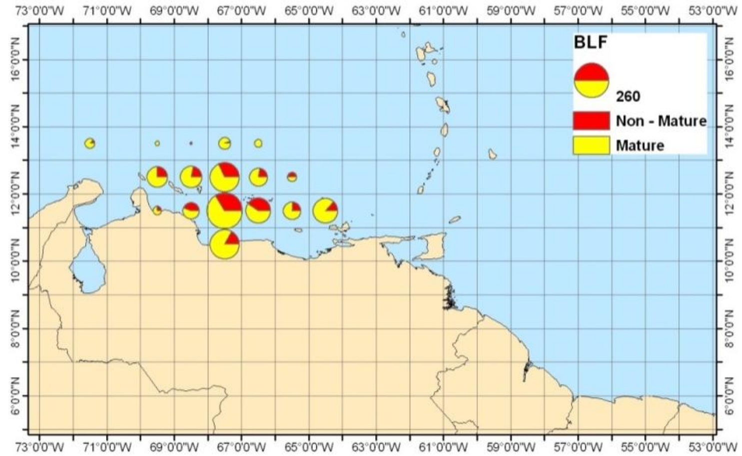

Q4

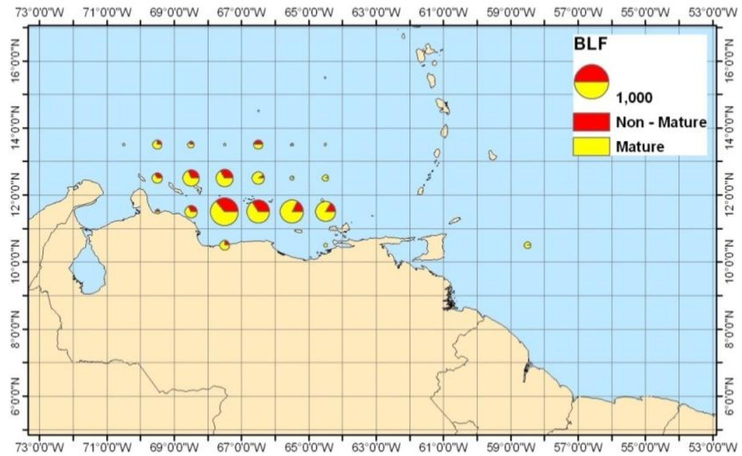

Figure 6. Temporal and spatial distribution of non-mature (<50 cm FL) and mature (>50 cm FL) blackfin tuna sampled catch from the combined Venezuelan industrial surface fleets.

Appendix 7: Report of the Data, Methods and Training Working Group (DMTWG)

1. Opening of the Meeting

Mrs. Anginette Murray served as Chairperson for the present meeting. The Chairperson opened the meeting at 9:15 a.m., and welcomed participants to this year's meeting. Noting that there were several new faces, the Chairperson invited participants to introduce themselves. The participants included representatives from Anguilla, The Bahamas (present for second session only) Belize, Grenada, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, Suriname, St. Vincent and the Grenadines, and Trinidad and Tobago.

In attendance also were 2 observers from NMFS SEFSC, an observer from OSPESCA, an observer from IC-NET, a consultant recruited by IC-Net to work on CARIFIS issues, two observers from JICA, and three CIDA interns. The two observers from JICA indicated that they were reviewing the progress of the CRFM-JICA Master Plan project, and so they were attending only that part of the Meeting dealing with review and discussion of the progress FAD and statistics pilot studies being carried out under the master plan project.

2. Review and Adoption of Meeting Agenda

In view of the time constraints of the JICA observers' schedule, the meeting agreed to begin with the two pilot study reviews, and it was agreed that these two reviews should be considered under agenda item 5.1. With this minor modification in timing, the agenda was adopted.

The Chairperson then finalized the rapporteuring arrangements as follows: Dr. Singh-Renton for items 1,2, 5.1a, 7 and 8; Professor Seijo for item 3; Ms. Headley (later changed to Ms. Masters) for item 4; Ms. Ferrier for item 5.2; Ms. Edwin for item 5.3; and Mr. Gongora for item 6. Working hours and timing of refreshment breaks were established.

3. Training Sessions

3.1. Training Seminar on Bioeconomics of the EAF (Ecosystem Approach to Fisheries) Management

A training seminar was presented by Dr. Juan Carlos Seijo on bioeconomic modelling and analysis incorporating multi-species and their bio-ecological interdependencies. It was pointed out that the bioeconomics of the ecosystem to fisheries should follow the following steps: (i) define fisheries management questions in the context multiple users of the marine ecosystem, (ii) identify possible ecological and technological interdependencies among species, habitats and fisheries within the ecosystem, (iii) select biological/ecological and economic/social performance variables of ecosystem use, (iv) define corresponding ecosystem performance indicators, (v) establish limit and target reference points for the indicators, (vi) identify alternative management, co-management and/or community management strategies for the fishery within an ecosystem context, (vii) design a dynamic bio-economic model of the ecologically and technologically interdependent fishery, (vii) collect data to estimate model parameters, (viii) identify possible states of nature in uncertain and sensitive parameters, (ix) build decision tables and apply decision criteria to deal with risk and uncertainty, (x) estimate probabilities of exceeding ecosystem limit reference points (risks) and of achieving desired target reference points, and (xi) build decision tables with and without mathematical probabilities.

It was also indicated in the course that in the transition from single species to EAF, while still focussing, as is inevitable, on collecting basic data for the economically most important species in the region, their assessments should monitor:

(i) changes in the abundances of their prey and predators through appropriate survey-based indicators,
(ii) changes in those environmental factors of importance to their life histories and,
(iii) changes in the dynamics of fishers and fleets behaviour when targeting predators, preys and, competing species.

During the course the steps presented above were illustrated with an exercise developed to consider a fluctuating stock fishery with predation mortality built-in. Two approaches for modelling stock fluctuating fisheries were considered:

(i) Use of a periodically varying carrying capacity to model the long-term dynamics of stock fluctuations.
(ii) Use of an environmentally driven recruitment function in an age structured bioeconomic Use a dynamic bioeconomic model of the fishery

Using the first approach a Monte Carlo Analysis was undertaken using the model spreadsheet distributed to participants, to estimate the biological and economical risks associated with alternative management strategies.

During the training seminar, management implications of dynamic fluctuating stocks in a context of ecological interdependent fisheries were also discussed.

4. 2010 - 2011 inter-sessional activities

Dr. Singh-Renton provided the meeting with an update of the inter-sessional activities undertaken by the CRFM Secretariat. These updates were as follows:

1. Flow of Information

A yahoo e-group was set up late December early January. The Secretariat was unable to set up a ListServe as it required additional resources: both financial and human resources. Ms. Maren Headley has been coordinating activities of the e-group.

The recommendation for the Newsletter was presented to the management of the CRFM Secretariat, and it was felt that since the CRFM already had a Newsletter, the CRFM Newsletter should be used such that there would be an annual Scientific Issue (produced from the Scientific Meeting (SM)) and a Management Issue of the CRFM Newsletter. Since the Forum has to endorse the report of the SM then the newsletter would be issued right after the Forum endorses the SM report.

It should be noted that two issues of the Scientific Newsletter have since been prepared – the first issue comprised of articles from the First to Fifth Annual SM and the second issue focused on articles coming out of the Sixth Annual SM.

2. CRFM Toolbox

A CRFM toolbox was established, as requested. The Toolbox is currently being housed on the CRFM's website. The first contribution comprises the R-course materials prepared and delivered by John Hoenig during the Sixth SM.

3. CRFM Notebook

A CRFM Notebook was established, as requested. The Notebook is currently being housed on the CRFM's website. The first contribution comprises an earlier assessment of the TCI conch fishery.

***Discussion**:*

Countries were asked to provide feedback on the Newsletter. Bahamas had indicated that the language was clear, and the articles are informative. There was however a correction to be made in Issue 1. Belize commended the effort and indicated that the content was reflective of the work done by the groups. Belize also called upon Member States to be more involved with the Secretariat in formulating the newsletter and encouraged Member States to take ownership of the next issue by taking a leading role in development of the next issue

Trinidad and Tobago asked if the methods in the tool box/notebook were the methods already used or if they were the methods to be used in the future. Dr. Singh-Renton pointed out that the tool box/notebook was not restricted, and if there was a method that participants wanted in the toolbox, it should be pointed out and the Secretariat would take steps to try to get it into the tool box.

The Chairperson pointed out that there was an unresolved issue as to where the material of the toolbox should be stored as it was currently being housed on the CRFM's website. Both the Meeting and the CRFM offered no objections to this and so it was agreed that it will remain. It was pointed out that the site is password protected and that the focal person leading the coordination of the toolbox is Ms. Maren Headley.

The lead person for the Scientific Issue of the CRFM news letter (the Scientific Meeting Issue) is also Ms. Headley. She has worked with others in the Office (Secretariat) to bring the language of the News Letter to where it should be and Miss Yvonne Edwin and Derrick Theophille has also provided input into the current issues. Dr. Singh-Renton also indicated that she welcomed the comments made by Belize, and noted further that the group could look towards rotating the leads for the issues of the News Letters. However since Miss Headley was the lead of the small coastal pelagics working group and the next issue would include the work of that group then perhaps Miss. Headley could continue to be the lead for the next issue.

5. Plenary session to review and discuss issues and recommendations pertaining to data, methods and training

5.1 Data

5.1.1 Review of CRFM-JICA statistics pilot study with emphasis on CARIFIS

This review was presented by the IC-Net contracted consultant to work on CARIFIS issues, Ms. Sherill Barnwell.

Presentation summary - prepared by Sherill Barnwell

The presentation began with a historical overview of CARIFIS and discussed a number of review sessions and training workshops which were held during the period July 2001 to October 2010. The purpose of these meetings ranged from developing CARIFIS' blueprint and the testing of alpha and follow-up versions of CARIFIS, to the Training of Trainers workshops. Funding was sourced from the CRFM, FAO, and JICA.

The presentation also talked about the major services provided from 2004 through the present. These services include the installation of appropriate hardware and software to host CARIFIS; compilation and distribution of training material to support the use of CARIFIS; in-country tailored training and technical assistance as requested; transfer of data from legacy LRS and TIP systems to CARIFIS. Additionally, mentioned was made of the attempt to enhance the querying and reporting capabilities of CARIFIS by integrating the Stonefield Query utility software.

The status of CARIFIS across CRFM participating countries was also considered. Countries in attendance were given the opportunity not only to comment on the information presented but also to give an update on the use of CARIFIS at their local Fisheries Divisions. In gist, a number of countries have implemented CARIFIS as their data management tool for fisher and vessel registration and also for catch and effort data. CARIFIS also operates on a multi-user level in a few countries. A couple of countries such as Dominica, Belize, and to some extent Barbados and Trinidad have applied the use of software other than CARIFIS to handle their data management needs.

The presentation continued by discussing some challenges common to users of CARIFIS. These include the querying and reporting facility; incompatibility with Windows 7 and Vista operating systems; retention of skilled and trained staffed through high staff turnover and lack of knowledge transfer; and absence of the dedicated support of a Data Manager at the CRFM level.

In closing the planned intervention and support to St. Vincent, from JICA/ICNET, for the period June to September 2011, was highlighted. These would include: the setting up of a number of queries and standard reports; resolving the Windows 7/Vista problem; considering the inclusion of census and FAD biological data into CARIFIS; and developing guidelines for the transfer of data from MS Excel to CARIFIS.

Discussion:

Mr. Gongora advised the Working Group that while Belize continued to have an interest in CARIFIS, Belize had recently developed an alternative database for managing its fisher and vessel licensing system. This new system was scheduled to be launched on 1 July 2011. During the second session of the Working Group, Mr. Gongora gave a PowerPoint presentation of the new licensing database, and suggested that it be given consideration by the CRFM as an alternative to CARIFIS. It was also clarified that the Belize database was based heavily on the CARIFIS structure. The Working Group noted the importance of consistency in database structure, regardless of what countries used.

Mr. Gittens indicated recent problems of incompatibility of the Stonefield software (used to query CARIFIS) with newer computer systems. A new software licence had to be purchased by The Bahamas in order to solve the incompatibility issue. Mr. Gittens suggested that consideration be given to CRFM providing support at the regional level for maintenance of both Stonefield and CARIFIS. The Chairperson noted that Jamaica had also experienced incompatibility problems with CARIFIS, and was anxious that attention be given to the upgrade of CARIFIS to meet evolving needs. Ms. Ferreira informed the Working Group that Trinidad and Tobago used CARIFIS to store fisher and vessel licensing and registration data, while catch and effort data were stored in an Oracle database. In recent years, only fisher data had been entered into CARIFIS, due to problems that remain unresolved. In addition, the fisheries legislation was being updated for Trinidad and Tobago. As a result, new data forms were being developed to meet anticipated expanded reporting obligations under the new legislation, and the additional data needs exceed what was contained in CARIFIS. At present, therefore, Trinidad and Tobago was considering shifting all data to a Microsoft SQL database.

Noting that CARIFIS worked for some countries while other countries preferred to use alternative database options, it was pointed out that the important issue was to ensure that countries were able to agree on minimum data reporting standards, which also inferred minimum standards for data collection. Ms. Mohammed reminded the Working Group of the need for data exchange among agencies within countries, and noted that this would have to be taken into account in respect of the structure and operation of any selected fisheries database. The issue of regular provision of training in CARIFIS was raised. It was noted that training was a responsibility not only of the Working Group but of the individual officers to ensure seamless transition when changes in staffing occurred.

The Chairperson asked about the timeline for further development of CARIFIS. The Working Group was reminded that CARIFIS, like other database software, would always be in need of development. The commitment of the countries would determine the pace and direction of the development. The working group was also reminded that the CRFM-JICA project was scheduled to end in November 2011, and that the ongoing work on development of CARIFIS was primarily being driven by the priorities identified at the two pilot study locations. It was therefore important to have dedicated support for CARIFIS, if there was agreement that the software should be continued. In this regard, the Working Group considered and agreed on the importance of filling the CRFM Secretariat position of Programme Manager, Statistics and Information.

5.1.2 Review of CRFM / JICA FAD pilot study

Review: This review was presented by Ms. Headley of the CRFM Secretariat.

***Presentation summary**:*

The Pilot Project for FAD and Associated Pelagic Fisheries Resource Development and Management in Dominica and St. Lucia is part of the JICA Study on Formulation of a Master Plan on Sustainable Use of Fisheries Resources for Coastal Community Development in the Caribbean. FADs (Fish Aggregating Devices) are any man made / partly man made floating or submerged device whether anchored, or not intended for the purpose of aggregating fish. The objectives of this pilot project are: i) to improve the capability of FAD fishery management on the part of the fisheries officers and fishers and; ii) Increase the productive output of the FAD by developing the skills and capacity to utilize potential species. The intended management approach is bottom up based on community participation involving fisher groups, individual fishers the Fisheries Division/Department, ICNet and CRFM.

FAD monitoring activities are a major component of the pilot project, necessary for informing the management process and cover: i) Catch and effort data collection; ii) Biological data collection; iii) Durability and maintenance requirements; iv) Cost performance and income generation. Data forms have been designed to record these activities in collaboration with the CRFM, ICNet and the Fisheries Division / Department counterparts. Factors such as strong currents, bad weather, limited catches, and miscommunication among Fisheries Division/Department staff and fishers have resulted in some data collection challenges. However, a monthly update activity sheet has been designed to reflect the progress of these activities, and identify where gaps are occurring so that they can be addressed in a timely manner.

Other major components of the pilot projects are:

- FAD technology development activities for economic / efficient use, non-submersion, long durability
- Fund generation activities (license & registration fees, collection of FAD user’s fee, fund management)
- Development of under/unutilized species (diamond back squid-DBS) and sensitization activities (flyers, brochures, tasting sessions)

- Development of a FAD Fishery Management Plan
- Finalization of FAD regulations and legislation

Management outputs which have been achieved so far are: i) Improved FAD fishery management in terms of economic efficiency and community participation; ii) Improved capability for data management of FAD performance and FAD target species catch; iii) Reduction in FAD user conflict ; iv) Improved capability of FAD fishery management, on the part of the fisheries officers and fishers in the target country; v) Development of fishery for unutilized/under-utilized species; vi) Increased productive output of FAD, by developing the skills and capacity to utilize all potential species; vii) Identification of fund generation activities; viii) Development of processing and marketing strategies for unutilized species.

Discussion:

No questions were raised on the presentation of the CRFM-JICA FAD study.

Additional discussions on data:

During the second session, Ms. Martin informed the Working Group of the problem of loss of data and information after being shared and considered by resource working groups for specific assessment tasks. She noted the example of the 2010 LPWG report that, though completed, did not reflect all the data compilation and information outputs produced during the LPWG's on-site meeting in 2010. Ms. Martin noted that for the 2011 LPWG meeting, the Dropbox facility was used to share data and information as it was produced. However, it was important to consider establishing a more permanent system for holding data and information produced by each working group session, and for facilitating access to this by working group members after meetings are completed. Ms. Martin suggested that a server could be set up for the purpose. Moreover, the 2011 LPWG session recognized that such a system would require dedicated support at the Secretariat level. In view of confidentiality issues pertaining to sharing of data, especially sharing of raw data, the Working Group was asked to re-evaluate the need for establishing a CRFM data policy. The need to establish a minimum standard for data reporting was also agreed.

Recommendations

1. The Working Group recommended that the CRFM Secretariat should conduct a simple survey to determine the interest of countries in continuing the use of CARIFIS, and in so doing, determine the nature and extent of support to be provided for CARIFIS at the regional level. The Working Group proposed that Ms. Masters of the CRFM Secretariat could undertake this exercise, and requested that it be completed by the end of July. Following completion of the survey, the Working Group would consider the result and way forward during the inter-sessional period.
2. The Working Group recommended that minimum data reporting standards, in the context of fishery assessment needs, be determined during the inter-sessional period. The Working Group further recommended that this task be coordinated by Dr. S. Singh-Renton and be completed by 1 October 2011.
3. The meeting called for a Programme Manager, Statistics and Information to be employed at the CRFM Secretariat who would drive data issues (including CARIFIS).
4. The Working Group recommended that a permanent system be established for holding data and information produced by each working group session, and for facilitating access by members of the working groups after meetings are completed and for future working group activities. The call for a server to hold data also makes the need for the Programme Manager, Statistics and Information more necessary.
5. The Group recommended that the Data Policy drafted by the group some years ago should be re-circulated for review by the group.

5.2 Methods

Trinidad and Tobago provided a brief update on the PARFISH project. It was explained that PARFISH was used in a biomass assessment model that was conducted in 2005 - 2006 under FAO and CRFM. Interviews from PARFISH were fed into this assessment, but when PARFISH data were left out the result of the assessment worked out to be about the same. It is currently being used to develop projections for different management rules, for example exploring the possible effects of a closed season. This project will be further explained in the plenary session.

It was explained that CRFM has been working with new methodologies to broaden the organization's approach to analysis and development management advice. Specifically, an ERAEF (Ecological Risk Assessment for the Effects of Fishing) study of the Dolphinfish fishery in the Eastern Caribbean is underway and is expected to be completed up to the PSA level by next year. For the Flyingfish fishery, Multi Criteria Analysis (MCA) is being applied as an assessment tool which includes both qualitative and quantitative data. The first stage of the MCA is completed, which involved soliciting stakeholder weightings of management objectives.

It was mentioned that R is now available as an add-on in Excel, which may increase the user-friendliness of the R software.

An update was given on the status of the age and growth study. In a previous meeting the forum endorsed resumption of the age and growth work and reaffirmed its support for age and growth work by committing a flat sum of $10,000 US/year to fund the lab. Canada is believed to be willing to fund a training session for a scientist to work in the age and growth lab in Canada, and a Memorandum of Understanding (MOU) was drafted between CFRM and the Institute of Marine Affairs. CRFM has signed the MOU, but the project is stalled because the IMA has not signed the MOU and finalized approval for the project.

5.3 Training

The working group acknowledged that while the R-statistical software has proven to be a useful tool, having a one-day training session at the Scientific Meetings each year was not entirely beneficial. This is due to the turnover in participants at each meeting. The subject of previous training needs in MS Excel was mentioned. It was suggested that individual countries make use of any training opportunities offered by their Governments in the use of MS Excel. While this was generally accepted it was however noted that these courses may not cover topics specific to our areas of interest. Consequently, the following were recommendations made by the working group to address these concerns:

- It was proposed that a one-week training session be held in "R" with the target audience being data management personnel. It is recommended that the CRFM Secretariat seek additional funding to facilitate this training programme which would be conducted outside of the Scientific Meetings.
- For the 8th Scientific Meeting, it is recommended that the day and a half training session be reinstated to address training in the use of MS Excel with emphasis on tools specific to data analysis.
- Each country should conduct a training needs assessment and submit to CRFM prior to the next Scientific Meeting.

6. 2011-2012 inter-sessional workplan

(a) The CRFM Secretariat will prepare regional minimum fisheries data requirements and will circulate to member states that are expected to review them in relation to fishers, boats and catch per unit effort reporting and data collection standards by 1 October 2011.
(b) The CRFM Secretariat will prepare a CARIFIS questionnaire sheet by the July 2011 and will submit to member states for their response so as to determine whether they support or not the continued use and / or upgrade of the CARIFIS database.
(c) Member states are requested to respond to the CARIFIS questionnaire by the end of August 2011.
(d) The CRFM Secretariat will prepare a proposal for a computer server that will be used for a regional fisheries data storage system and develop a data policy to ensure that the integrity and confidentiality of the data is maintained. This proposal will be presented to the next Forum Meeting.
(e) The CRFM Secretariat is being recommended to seek and secure funding for the development and implementation of a one-week training course on the use of R statistical program.
(f) Member states will develop a list of their training needs at the national level and share with CRFM and members states by the end of December 2011 in preparation for the 2012 CRFM Scientific Meeting.
(g) Meeting participants from member states will make every effort to compile the relevant fisheries data sets for their countries for analysis at the next CRFM Scientific Meeting even if they are uncertain who will participate in the meeting.

7. Any other business

No additional business matters were tabled for the Meeting's consideration.

8. Adjournment

Participants thanked the chairman for her efforts in ensuring a successful meeting. The plenary session adjourned at 12:20pm on 23 June 2011.