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CRFM Fishery Report - 2007

Volume 1

Report of Third Annual CRFM Scientific Meeting - St.Vincent and the Grenadines, 17-26 July 2007

CRFM Secretariat,
Belize
2007

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Foreword

The 2007 CRFM Annual Scientific Meeting took place during 17-26 July 2007. During this Meeting, CRFM Resource Working Groups examined data from eleven fisheries: the Nassau grouper (*Epinephelus striatus*) fishery of Belize; the queen conch (*Strombus gigas*) fisheries of St. Lucia and the Turks and Caicos Islands; the spiny lobster (*Panulirus argus*) fisheries of Jamaica and the Turks and Caicos Islands; the shrimp (*Farfantepenaeus subtilis* and *Farfantepenaeus brasiliensis*) fishery of Suriname; the Atlantic Seabob (*Xiphopenaeus kroyeri*) fishery of Guyana; the bangamary (*Macrodon ancylodon*) fishery of Guyana; the seatrout (*Cynoscion virescens*) fishery of Guyana; the king mackerel (*Scomberomorus cavalla*) fishery of Trinidad and Tobago; the wahoo (*Acanthocybium solandri*) fishery of the Eastern Caribbean. The Meeting also reviewed and adopted the Report of the Second Meeting of CRFM's Ad Hoc Working Group on Methods. A working draft of a CRFM Data Policy Outline was also reviewed and discussed during the Meeting.

The Report of the 2007 CRFM Annual Scientific Meeting is published in two Volumes: Volume 1 contains the proceedings of the plenary sessions and the full reports of the CRFM Resource Working Groups for 2007. National reports, submitted for consideration by the Meeting, are published as Supplement 1 to Volume 1, while the Report of the Second Meeting of the Ad Hoc Working Group on Methods is published as Supplement 2 to Volume 1. Volume 2 contains the fishery management advisory summaries, which are the same as the first 7 sections (sections 1 to 1.7) of each of the fishery reports that are provided in full (sections 1 to 1.8) in Volume 1.

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.

List of Acronyms and Abbreviations

ACP	African, Caribbean and Pacific States
ANOVA	Analysis of Variance
ARGOS	Advanced Research and Global Observation Satellite
BFD	Belize Fisheries Department
CARICOM	Caribbean Community
CARIFORUM	Caribbean Forum of ACP States
CARIFIS	Caribbean Fisheries Information System
CERMES	Center for Resource Management and Environmental Studies
CFF	Caribbean Fisheries Forum
CFP&R	Common Fisheries Policy and Regime
CFRAMP	CARICOM Fisheries Resource Assessment and Management Programme
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CL	Carapace Length
CLME	Caribbean Large Marine Ecosystem
CLWG	Conch and Lobster Resource Working Group
COTED	Council for Trade and Economic Development
CPUE	Catch Per Unit of Effort
CRFM	Caribbean Regional Fisheries Mechanism
CSME	CARICOM Single Market and Economy
DECR	Department of Environment and Coastal Resources
DFID	Department for International Development (UK)
DOF	Department of Fisheries
EEZ	Exclusive Economic Zone
ERAEF	Ecological Risk Assessment for the Effects of Fishing
FAO	Food and Agricultural Organization of the United Nations
FISMIS	Fisheries Management Information Systems
FL	Fork Length
GDP	Gross Domestic Product
GIS	Global Information Systems
GLM	General Linear Model
GloBAL	Global Bycatch Assessment of Long-Lived Species
GPS	Global Positioning Systems
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICLARM	International Center for Living Aquatic Resources Management
IMA	Institute of Marine Affairs
JICA	Japan International Cooperation Agency
LEK	Local Ecological Knowledge
LFDA	Length Frequency Distribution Analysis
LPWG	Large Pelagic Fish Resource Working Group
LRS	Licensing and Registration Systems
MCMC	Monte Carlo Markov Chain Methods
MEY	Maximum Economic Yield
MOU	Memorandum of Understanding
MPA	Marine Protected Areas
MRAG	Marine Resources Assessment Group
MS	Microsoft
MSY	Maximum Sustainable Yield

MT	Metric Tonnes
NGO	Non Governmental Organizations
NOAA	National Oceanic and Atmospheric Administration
OTC	Oxy-tetracycline
RAPD	Random Amplification of Polymorphic DNA
RSWG	Reef and Slope Fish Resource Working Group
SAFMC	South Atlantic Fishery Management Council
SEFSC	Southeast Fisheries Science Center
SGWG	Shrimp and Groundfish Resource Working Group
SPAG	Spawning Aggregation Working Group
SPR	Spawning Biomass Per Recruit
SPSS	Statistical Package for the Social Sciences
TAC	Total Allowable Catch
TED	Turtle Excluding Device
TEK	Traditional Ecological Knowledge
TCI	Turks and Caicos Islands
TIP	Trip Interview Programme
TL	Total Length
UNU-FTP	United Nations University Fisheries Training Programme
USA	United States of America
USD	United States Dollar
UTT	University of Trinidad and Tobago
UVC	Underwater Visual Census
UWI	University of the West Indies
VMS	Vessel Monitoring Systems
WCA	Western Central Atlantic
WECAFC	Western Central Atlantic Fisheries Commission
WTO	World Trade Organization
WWF	World Wildlife Fund

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REPORT OF THE
CRFM ANNUAL SCIENTIFIC MEETING 2007

1. Opening of the meeting

The Meeting was formally opened by the Chief Fisheries Officer of the Fisheries Division of St. Vincent and the Grenadines, Mr. Raymond Ryan in the Ministry of Agriculture, Forestry and Fisheries. Mr. Milton Haughton, Deputy Executive Director of the CRFM Secretariat, also addressed the participants. Mr. Haughton took the opportunity to remind participants of the purpose of the CRFM, as well as ongoing initiatives by the CRFM. Dr. Susan Singh-Renton, Programme Manager, Research and Resource Assessment, CRFM Secretariat, gave the vote of thanks.

2. Election of chairperson

One of the representatives from the Fisheries Division in Trinidad and Tobago, Ms. Suzuette Soomai, nominated Mr. Raymond Ryan to serve as Chairperson of the Meeting. This proposal was seconded by a representative from Guyana, Ms. Pamila Ramotar.

3. Adoption of meeting agenda and meeting arrangements

The agenda was presented. CRFM Secretariat advised the meeting that the Secretariat had prepared two documents for consideration by the Meeting, titled 'The CRFM Fisheries Tagging Programme' and 'CRFM Data Policy Outline'. It was proposed that these documents be addressed either at Agenda Item 8 or Item 13. The meeting agreed to discuss the Secretariat document under Item 8. The meeting agenda was adopted with these minor additions (Appendix 1).

4. Introduction of participants

The Chairman invited participants to introduce themselves to the meeting. A list of participants is provided in Appendix 2.

5. National (country) reports

National reports were submitted by the following countries: Anguilla, Belize, The Bahamas, Guyana, Jamaica, St. Lucia, Suriname, and Turks and Caicos Islands. The representatives from Montserrat and Trinidad and Tobago advised the Meeting that they would submit their national reports during the course of the meeting. It was agreed to extend the deadline for submission of national reports to 3 August 2007. National reports are published as Supplement 1 to Volume 1 of this Report.

6. Review of Report of the Second Meeting of the CRFM Ad Hoc Working Group on Methods

The Chairperson of the Second Meeting of the CRFM Ad Hoc Working Group on Methods, Mrs. June Masters, presented the Report of this Meeting (published as Supplement 2 to Volume 1 of this Report).

A query was raised regarding the progress of inter-sessional testing of the methods introduced so far. The meeting was advised about some progress in inter-sessional tests of the survival method using data from

Guyana and The Bahamas. Additionally, Secretariat staff were collaborating with fisheries staff from St. Vincent and the Grenadines in testing the ERAEF method for data available on the local lobster fishery. Participants were urged to continue their inter-sessional work and to try to complete all outstanding inter-sessional activities prior to the final meeting of the Ad Hoc Working Group, scheduled to take place later in 2007.

Participants were reminded that both Dr. Hoenig and Dr. Hobday's contracts included a time allocation for inter-sessional consultation, and that this time allocation ended on 31 August 2007. If required, participants should advise the Secretariat if this deadline needed to be extended.

Regarding the recommendation for the Secretariat to facilitate training in data analysis, the Meeting was reminded about the training opportunities afforded by ICCAT to developing states that are members of ICCAT. It was pointed out that ICCAT was able to provide training in data collection, sampling, as well as some aspects of stock assessment, as needed. It was suggested that CRFM countries that are members of ICCAT should prepare a proposal for submission to ICCAT. The Secretariat confirmed that countries had been advised of the available ICCAT training opportunities, but no responses had been received to date. The meeting agreed that it was important for countries to identify their particular training needs and state of readiness to facilitate development of a proposal for submission to ICCAT. Such a proposal could be developed by the Secretariat, following approval by those CRFM member States that are members of ICCAT. The Meeting was also informed about short-term training courses offered by UWI that were designed for 'career persons' who would like to receive training but who could not devote more than 1-2 months of their time to this.

In addition to the report's recommended reference sources for improving communications among scientists, managers and stakeholders, the Meeting was reminded of an additional useful guidebook produced by FAO, titled, 'A Fishery Manager's Guidebook'.

The meeting noted that the report of the Working Group was already available online in pdf format. The report of the Second Meeting of the Working Group was adopted.

7. Reports of the CRFM Fisheries Working Groups

7.1 Conch and Lobster Resource Working Group (CLWG)

The full report of the Working Group is given in Appendix 3.

7.1.1 The spiny lobster (*Panulirus argus*) fishery of Turks and Caicos Islands

In terms of general comments, the rapporteur was advised to simplify further the language of the management summary, so as to minimize the use of technical language as far as possible. In addition, the rapporteur was urged to include information on the value of the fishery and if possible, to relate the management advice to economic benefits. A query was raised regarding the economic impact of having the TAC fluctuate throughout the year. It was explained that some fishers were part-time only, and these part-time fishers were the ones who would take advantage of any available extra TAC whenever it would be allowed. Another query was raised regarding the format of the fishery report, and whether it was more appropriate to have the policy summary section at the beginning of the report. The Meeting agreed that the Working Groups could consider this change for future reports. It was also suggested that the Working Groups could consider including a section to deal with policy implications that emerge from the scientific findings.

7.1.2 The queen conch (*Strombus gigas*) fishery of the Turks and Caicos Islands

The Meeting noted the need to improve the clarity of the language of the report in certain parts. A query was raised regarding the management advice statements that referred to a 13-year old study, which appeared to conflict with the results of the more recent assessment. It was clarified that the present data could not be used to determine if local depletion was taking place, and it was suggested that a recommendation be added to address examination of the spatial pattern of exploitation.

The meeting was reminded of CITES recent interventions regarding the management and trade of queen conch, including Brazil's recent position on spiny lobster. The CRFM Working Groups were urged to monitor carefully the status of their conch and lobster fisheries in light of these developments.

7.1.3 The queen conch (*Strombus gigas*) fishery of St. Lucia

A query was raised regarding the apparent contradiction between the text of the report that suggested that no overfishing was taking place and that current catches could be maintained and a figure in the report that showed a declining CPUE trend. This was clarified by pointing out that the current catch was less than the replacement yield. Having said this, it was noted that the analysis was similar to that conducted for the TCI stock, and that the problem was probably weaker data in the case of the stock for St. Lucia. The difference in the effort unit used to monitor the TCI and St. Lucia stocks was also pointed out. Another query sought clarification about the choice of CPUE and its consistency with depth. It was confirmed that the available CPUE could not be corrected for depth as depth data were not available. However, other CPUE indices gave similar results. It was also proposed that scientific criteria should be developed to select the priors to be used, and that the priors could also be improved from improving general knowledge on the local biology and ecology of the resource. In respect of the recommendation to undertake a habitat mapping study, clarification was sought about the options for its implementation. It was noted that the mapping study was quite important for developing good priors, and could be justified because the information gained from such a study could yield a shared benefit for other countries in the region.

The Meeting noted that the recommendations, as stated, were not sufficiently clear, with respect to management, research and a time frame for their implementation and completion. In addition, the need to prioritize recommendations was emphasized. It was also noted that there was insufficient time to develop any detailed research proposals at this meeting. The meeting was advised of the possibility of exploring options to integrate the recommended mapping study with coastal zone management and participatory GIS initiatives, which could help to defray some of the costs.

7.1.4 The spiny lobster (*Panulirus argus*) fishery of Jamaica

There was some concern about the poor quality of data and the lack of reference to previous assessments and to historical data and studies in order to try and improve understanding of the fishery and its current status. It was noted that the existence of legislation was an indication that the government was concerned about the status of the lobster stock at some point in time, and that examination of the historical literature would provide further information on developments in this regard. It was clarified that the management advice provided in the 2007 report was based only on analyses completed during the previous week's Working Group session. The meeting agreed that it was essential to consider the present results in the context of previous assessments, but also to avoid too much replication.

Regarding the recommendation to develop a conversion factor from carapace length to tail length, it was pointed out that tail length measurements were not very accurate. The rapporteur clarified that carapace length would still be collected, and the conversion factor was largely required to provide additional information only in those situations for which carapace length was not available. In respect of the ongoing initiative to introduce casitas, the importance of making the connection between the type of operation, co-management and policy for the successful operation of casitas required specific conditions. The rapporteur confirmed that the government of Jamaica had already begun exploring the introduction of casitas, and that there was a need to provide information on the benefits and sustainability of casita operations.

It was pointed out that the recommendations pertaining to data improvements were not clear in the draft, and the rapporteur was asked to ensure this was addressed in the final version of the report.

7.2 Shrimp and Groundfish Resource Working Group (SGWG)

The report of the Working Group is given in Appendix 4.

7.2.1 The Sea Trout (*Cynoscion virenscens*) fishery of Guyana

The meeting discussed the need and agreed that for future reports, the Policy Summary section should be placed at the beginning of the report, and policy questions and implications, as these related to technical results, should be placed after section 1.6.

It was also suggested that based on the reference point given (50% of unexploited biomass), that the report should provide the actual value for this reference point. Additionally, there was a query regarding the recommendation to conduct an analysis of otoliths, and it was clarified that a feasibility study would be performed initially. Another query was raised in respect of the age information quoted in the results, and it was explained that these were 'best guesses' that would be explained in the detailed report.

7.2.2 The Bangamary (*Macrodon ancylodon*) fishery of Guyana

It was noted that this assessment was building on work previously covered in WECAFC assessments, and that it was important to include references to earlier work completed. Based on this comment, supported by several participants, the Meeting recommended that the Secretariat ensure that copies of the WECAFC assessments and other previous relevant assessment reports be made available to the Working Groups, as well as development of comprehensive bibliographies to facilitate the annual assessments. The Meeting made a request to the FAO representative to consider making such reports available online. Additionally, it was proposed that the Secretariat could prepare species synopses, similar to the ones prepared by FAO. The idea of developing a meta-database was also raised. In response, the Secretariat suggested that these recommendations were useful, and should be discussed and developed at the Next meeting of the Ad Hoc Working Group on Methods. In view of time constraints during the scientific meetings, the need for scientists to conduct literature reviews during the inter-sessional period was also emphasized. There was some discussion about the difficulties in accessing literature experienced by scientists within CRFM countries. A suggestion was made about developing a network that would facilitate exchange of literature online via the internet; such a network could also include linkages to the FISMIS system operated by the Fisheries Division in Trinidad and Tobago. The idea of provision of training in library science was also raised for consideration.

7.2.3 The Atlantic seabob (*Xiphopenaeus kroyeri*) fishery of Guyana

It was pointed out that there was some inconsistency in the management advice provided in 2006 with that given in 2005. It was clarified that due to time constraints, the analysis completed this year was not as complete. Efforts would be made to complete the analysis and adjust the management advice, if found necessary. There was also concern that the analysis only examined data from the pre-management period, and the importance of examining data for both time periods and conducting comparisons was recognized. Such a comparison would facilitate determination of the efficiency of the current management measure, which was especially important as a change in the measure was being recommended. It was clarified that comparison of the two time periods was possible but the market category data were not considered to be very accurate, and the results could be inconclusive.

There was also discussion about the primary reason for the current closed season, and whether it was intended to protect recruitment of seabob or other shrimp species. However, it was clarified that seabob was the main target of the fishery studied in the present analysis.

A general note was made regarding the need to maintain memory of previous work and conclusions. The meeting agreed that future reports should include a section to cover previous management advice, and this could be reproduced from the relevant section of the previous year's report. Following some discussion about the need for feedback on management actions taken in response to recommendations from previous assessments, it was recommended and the meeting agreed that national reports could include a section to cover new management regulations. The problem of communications among scientists, managers and stakeholders was raised, and it was pointed out that scientists are often unfamiliar with their own national fishery management objectives. The question was raised whether this issue could be addressed at the level of the CFF, and the Secretariat confirmed that this would be possible.

7.2.4 The shrimp (*Penaeus subtilis* and *P. brasiliensis*) fishery of Suriname

The rapporteur was advised that it was important to include in the report the fact that there had been a reduction in fleet size since 2000 and that this could explain the observed reduction in fishing mortality. Additionally, it was argued that the closed season should be established during July-August as the data clearly indicated that this time coincided with the main pulse of recruitment.

The rapporteur reiterated the importance of the Secretariat being able to provide copies of the reports of previous WECAFC assessments. Notwithstanding, it was pointed out that CRFM scientists should try to access these reports inter-sessionally. Another option would be for the Secretariat to provide scientists with the online sources for accessing the relevant documents.

7.3 Reef and Slope Fish Resource Working Group (RSWG)

Details of the Working Group Report are given in Appendix 5. In respect of the Chairman's report, it was pointed out that St. Vincent and the Grenadines was not present at the previous scientific meeting, and so the report should not contain any reference to selection of and assessment of the red hind fishery of St. Vincent and the Grenadines. The meeting agreed to exclude this reference.

7.3.1 The Nassau Grouper Fishery of Belize

Details of this presentation are given in Appendix 5. A query was made about the fishers' reactions to the closing of the spawning aggregation sites with regard to the other species. It was indicated that the Belize Spawning Aggregation Working Group (SPAG) had a public education awareness programme, which highlights the benefits of conserving and protecting the marine environment. A query was made about the status of protection offered to the nursery grounds given the fact that effluent from aquacultural activities could have a negative impact. It was indicated that with respect to Nassau Grouper, the reef was the main nursery area and the implementation of marine reserves was considered to offer significant protection.

7.4 Large Pelagic Fish Resource Working Group (LPWG)

The report of this Working Group is given in Appendix 6.

Details of the Chairman's report are given in Appendix 6. A query was made regarding the implementation of CARIFIS among the countries. It was pointed out that the Caribbean Fisheries Forum meetings spent the majority of time on administrative issues and not enough time was allotted to fisheries management work; the CRFM was considered too vital not to ensure that the fisheries management component was not addressed properly. Concern was raised regarding the inconsistency in data submissions from year to year, and in the data brought to the meetings by the rapporteurs. This reflected a lack of understanding of the need for some basic level of data sharing among countries. In this regard, the meeting was reminded that in the case of ICCAT, it was only merged sets of raw data that were destroyed after the analyses. Clarification was sought about the method applied by ICCAT to ensure destruction of raw data merged temporarily to facilitate particular data analyses. In response, it was confirmed that after the analyses of raw data are completed by ICCAT, the relevant merged dataset is simply deleted from each computer. A query was raised about the contribution of data from countries where these were not the most important fisheries. It was clarified that for incidental fisheries, the data would probably not be suitable for examination of CPUE trends, but they were useful for estimating total harvest.

Regarding the recommendation for CRFM to invite non-CRFM countries to the scientific meetings, it was pointed out that these countries were always invited but their participation was not funded by CRFM. Despite the constraints, it was suggested that the best available data be used in the assessments to demonstrate CRFM's commitment to the process and by this means, encourage the participation of non-CRFM countries. The provision of previous meeting reports, along with the invitations to non-CRFM countries, was suggested as a possible way of generating interest in participating in the CRFM scientific meetings. A query was made as to whether the ICCAT issues mentioned in the report related to assessment only. It was clarified that the species examined were included in ICCAT's mandate, and in view of this, it was important to keep ICCAT informed of our data analysis results, as well as any management recommendations agreed at the CRFM level. Within ICCAT, there are now procedures for review and acceptance of species assessment results generated outside of the ICCAT forum, but which would be of direct interest to ICCAT. It was also pointed out that different strategies would be required for coordinating assessment and management of the different large pelagic species. Notwithstanding, the Working Group agreed that local level fishery trends should be examined, and these results should be shared with ICCAT and by this means, promote the involvement of other States which may be harvesting the same stocks. It was highlighted that management decisions made by CRFM countries, once sanctioned by ICCAT, have the potential to place pressure on neighbouring non-CRFM states to co-operate with these measures.

7.4.1 The king mackerel (*Scomberomorus cavalla*) fishery of Trinidad and Tobago

The use of limit reference points and the possible confusion with a precautionary approach was queried and clarification was sought regarding the values of F20% SPR values. It was agreed that the report would be amended to clarify the interpretation of the F20% SPR value.

The validity of the F20%SPR values was questioned and it was indicated that analysis utilized length frequency data, and that the 20% limit was selected to be consistent with last year's reference point. A concern was raised regarding managers' handling of the advice pertaining to the reference point and the uncertainty surrounding its estimation. A "ramp" function for the decision rule was suggested as a more useful alternative, to enable managers to consider and make gradual shifts in their management strategies in response to fishery status shifts that would require management action.

7.4.2 The wahoo (*Acanthocybium solandri*) fishery

It was indicated that the issue of collaboration among countries with respect to the large pelagics was overstated. The meeting was informed that the issue of Associated Member Status was discussed at the 2006 Forum, and also COTED. COTED noted the reservations of three countries, and due to these reservations, the Forum decided that this issue would not be pursued further this year.

The issue of CARIFIS was raised and the meeting was reminded that CARIFIS was developed as a national rather than regional database. The meeting was advised that the issue of a regional database was being considered in collaboration with the Japanese (a project proposal submitted to JICA about 7 years ago). In response to comments about the difficulties countries were facing with the use of CARIFIS, it was clarified that assistance was being provided to countries, as requests were received by the Secretariat.

It was clarified that the point of CARIFIS was raised with respect to providing a common format of data rather than a regional database. It was also indicated that there was a general unawareness of the Japanese aided proposal. The fact that there was a communication problem was acknowledged and it was suggested that officers can access technical and administrative reports which are currently online.

The working groups were commended for their efforts in preparing the reports.

8. Review and discussion of Working Group recommendations to improve statistics and research inputs

8.1. CRFM Fisheries Tagging Programme Proposal

The proposal prepared by the Secretariat is given in Appendix 7.

It was noted that such a programme would be especially useful for wahoo, given the need for information on migration and stock distribution. In view of the fact that there are tagging programmes being conducted in the region, the meeting agreed that it would be useful to have these organized under a regional 'umbrella' programme. The option for collaboration with IMA for validation studies, especially with respect to the large pelagics and OTC marking was suggested for consideration. The point was made that historical tagging data should be included in the database, as there have been many previous studies, including a CFRAMP implemented one. It was also argued that such a programme could provide reliable growth parameters once there was a substantial amount of data. Furthermore, if the tagging was done in pulses between recruitment, then fishing mortality could also be determined. The meeting was advised that tagging data were available for some of the shrimp and groundfish resources of Suriname and for king mackerel in Trinidad and Tobago. It was agreed to revise the proposal to include mention of these two studies. Additionally, the possible linkage to other regional and international tagging programmes was pointed out, which could include data sharing, e.g. the bluefin tagging programme conducted by recreational fishers, the data of which were available to Duke University.

There was some concern about the high cost associated with implementing tagging studies. It was clarified that the regional programme was simply being established initially; specific project proposals would be developed in response to research priorities identified by the scientific meetings, and funding would have to be sought.

The Meeting supported the proposal to establish the programme and recommended that it be forwarded for consideration by the Forum.

8.2 CRFM Data Policy

The Secretariat prepared a draft data policy outline for consideration by the Meeting.

There was general concern about the inadequate resources currently allocated to data collection in countries, in view of their social and economic importance. However, the importance of quantifying and demonstrating the use of data was also highlighted. It was argued that a good sampling strategy would ensure that good data are obtained even in situations where there were limited resources. In view of this, it was suggested that the CRFM Secretariat could assist countries with revision of sampling strategies, as required.

It was noted that in preparing a data policy, the types of data and the level of sharing should be specified. The meeting agreed that data management should match the country's priorities. It was noted that with respect to aggregate data, data sharing generally posed no problems. However this was not the case with raw data, which were sometimes needed to facilitate more accurate analyses of shared stocks. The Meeting was reminded that detailed discussion of the policy was not necessary or desirable at the present time. The Meeting was asked to review the main components of the policy and to advise on major omissions in respect of these and/or any listed sub-components.

It was noted that in most cases the critical issue was a lack of resources rather than appropriate policies. Additionally, the policy should make provisions for collaboration with other organizations and projects. The issue of data ownership was raised and it was suggested that "ownership" be replaced with "protection," since the issues of concern would include, inter alia: data type and format, i.e averages or raw data, database structure, and usage. It was suggested that discussion of the data policy outline could be continued via email and it should also be given further consideration at the next meeting of the Ad Hoc Working Group on Methods.

The working draft of the Data Policy Outline, as amended by the Meeting, is given in Appendix 8.

8.3 Specific recommendations based on issues arising from Working Group sessions

Following review of Working Group Reports, several issues were raised, for further consideration and development during the next meeting of the Ad Hoc Working Group on Methods.

The importance of reviewing sampling design to improve efficiency and flexibility depending on the field situation was emphasized. It was recommended that this issue be given further consideration at the next meeting of the Methods Working Group. Additionally, the meeting was informed of a new stock assessment method currently being developed by FAO, which was able to make use of long time series of catch data; this method assumed that fisheries followed a particular type of development. It was also suggested that further consideration should be given to standardizing the development and establishment of informative priors used for Bayesian approaches that would facilitate improved understanding of the level of confidence in estimates, simulation tests and sensitivity analyses. It was agreed that these issues would be given further consideration at the next meeting of the Ad Hoc Working Group on Methods, which was expected to be the final meeting of that Working Group. In addition, the need for developing a permanent working group to address continuing issues pertaining to data and methods would require consideration during the next meeting of the Working Group on Methods.

Interviewing individuals utilizing rapid assessment forms was also suggested as a method of data collection and it was noted that this was particularly useful when there was a lack of financial resources. It was suggested that these types of data could be collected annually, while detailed studies could be done during longer time frames. A request was made to make the relevant documentation of this method available to the Ad Hoc Methods Working Group in preparation for its final meeting.

A query was made regarding the effectiveness of stock assessments in managing stocks. In response, it was noted that management of the queen conch stock of TCI has been very successful because of the available stock assessment results. It was noted that the problem with stock assessments was that the quotas recommended by the scientists were not usually included in the policies. The Meeting was reminded that the issues associated with communication between managers and scientists were addressed at the Methods Meeting.

Concern was raised regarding the use of CARIFIS and the problems experienced by other countries. It was noted that some countries were experiencing problems, which were usually minor, but knowledge of programming was required to fix them. In one country, it was noted that TIP was never used and a lot of problems have been encountered with LRS. In another case, it was noted that the country utilized only part of CARIFIS, with another database being used to obtain fishers' IDs and information.

It was noted that the CARIFIS programme was a good one, and its common data structure would facilitate more easily the implementation of any regional data policy. Some patience for sorting out the problems was required. It was indicated that the Secretariat had been unable to recruit someone with the complete skills required to fix the problems associated with CARIFIS. However, a consultant had visited the countries which indicated that they required assistance.

In order to address these problems, the meeting discussed the following suggestions: the development of an e-group; and specialized training of a few people from the region who could then offer assistance to other countries. The Meeting was informed that a locally based person was necessary to address the problems associated with CARIFIS and that an e-group was not a feasible solution as the cause of a specific problem could be too varied. The possibility of remote fixing was suggested. It was confirmed that this was a possibility, but it required financial resources. It was suggested that the Secretariat consider this option. It was also suggested that a single database be developed and maintained centrally. However it was noted that a highly trained person was necessary for this, as database management required highly specialized skills.

9. Special lectures

9.1 IMA fish growth studies

Details of this presentation are given in Appendix 9. It was suggested that during presentations, care should be taken in giving explanations, since it was stated that one country took wahoo of smaller sizes when compared to another. Clarification on this statement was sought and it was indicated that the otolith samples received by the lab from one country were from younger wahoo, whereas the otoliths from the other country were from wahoo captured in tournaments, and would have therefore been considerably older.

The meeting recommended and endorsed; the following items

i. The development of a Memorandum of Understanding (MOU) between the IMA and the CRFM Secretariat.
ii. The preparation of a proposal by IMA to address age and growth studies identified as priority by the CRFM Scientific Meetings so far. It was also suggested that the proposal be ready for presentation and review at the Third Methods meeting.

9.2 Socio-economic monitoring by Caribbean authorities

Details of this presentation are given in Appendix 10. The meeting noted the need for consideration of the information presented and how it could be incorporated into the assessments conducted during CRFM scientific meetings.

9.3 CARICOM's Common Fisheries Policy and Regime

Details of this presentation are given in Appendix 11. A query was raised concerning the availability of documentation on the Common Fisheries Policy and Regime. It was noted that the document was available on-line as well as in hard copy. The meeting was also advised that updates were currently being made to the document by a consultant. Clarification was sought regarding the following quotation in the report: "Decided that the elaboration of the Common Fisheries Regime would be independent and separate from and without prejudice to the settlement of maritime boundary disputes between and among Member State and Third Parties." It was indicated that this quote was made by the Heads of Governments, as a result of two boundary disputes which were in the process of being resolved at the time. It was pointed out that the difficulties associated with common access and boundary limits were understated.

10. Network partnership activities

10.1 Project GloBAL: Global Bycatch Assessment of Long-Lived Species

Details of this presentation are given in Appendix 12. It was noted that GloBAL's interpretation of by-catch may not be applicable to the fisheries within the CRFM region since by-catch is usually utilized. A query was made about the possibility of capacity building for officers of national fisheries departments/divisions involved in the project. It was clarified that capacity building was not the focus of the GloBAL project. However the meeting was made aware of the following options for training:

i. The operation of a GloBAL fellows programme during the summer
ii. Training in marine GIS, which was currently being considered in collaboration with FAO

iii. The possibility of collaboration with persons from Mexico to develop a joint GIS training session
iv. Tools for Arc were also currently being developed for distribution

The issue of the existence of data protocols for sharing data provided by countries was raised. It was indicated that MOUs could be developed, specific to each country and depending on the level of sensitivity of the data. It was indicated that an MOU had already been developed for Venezuela and covered among other things; ownership of data, publications and derivative products which could be developed. In conclusion, it was suggested that the issues of data sharing be addressed under the Data Policy item of the Agenda and it was agreed that it would be more convenient for countries to work under a common regional data policy. It was suggested that the usefulness of the information provided by this project in linking management and policy decisions be investigated.

Since the project focuses on collaboration, the comment was made that maybe a data template may have been preferable. An inquiry was also made about the consequences of not providing the correct data. In response to these issues, it was confirmed that several attempts to make linkages, prior to this meeting were made and discussions with the steering committee and persons from the region indicated that the development of country profiles was the best approach. It was highlighted that by-catch was an international issue and there was concern about regional activities; therefore, it would be in the country's best interests to ensure that the data were accurate.

A query was raised regarding the possibility of a country providing its own objectives. It was noted that this specific project did not offer this flexibility. However, it was suggested that there were other groups under which this could occur. An inquiry about the types of outputs and the development of a database, which could be accessed for use in ecosystem-based analyses, was made. It was noted that the current scope of the project did not include database development. However, if there was an interest in this, then such interests could be facilitated since the resources were available.

It was argued that by-catch was an issue for the bottom trawling fisheries and measures such as TEDs (Turtle Excluding Devices) had been incorporated into gear; in respect of this, the project was considered to be very useful. The importance of the data sharing policy was raised again and it was suggested that further discussions be held after the Data Policy document was presented.

10.2 The United Nation University-Fisheries Training Program

Details of this presentation are given in Appendix 13.

A clarification was sought regarding the 'age' eligibility criteria, which was listed as "old." The upper limit of this criterion eligibility was around 40 years. An interest in the provision of training opportunities for students of the University of the West Indies was expressed. It was also noted that the overlap between training being offered by ICCAT and the Fisheries Training Program should be taken into consideration and assistance in training was also offered by one of the consultants. A query was made about the possibility of having a one day training course during the Third Annual Methods meeting. However, this was not considered to be feasible given the fact that within the two week training courses, substantial compression of training material already occurs. There was also a query regarding the selection process of candidates and it was noted that this was discussed at the forum.

11. Identification of assessment needs and Working Group rapporteurs for 2007-08 time period.

The following table provides the list of fisheries proposed by Working Groups for review during 2007-08. The fisheries listed below, together with the management questions, require confirmation by the relevant national fisheries authorities.

Working Group	Fisheries
CLWG	(i) Spiny lobster fishery of Jamaica, following completion of proposed inter-sessional activities (ii) Spiny lobster fishery of St. Lucia, following completion of proposed inter-sessional activities (iii) Spiny lobster fishery of The Bahamas- required to be carried over (iv) Lobster fishery of the TCI – updated assessment only
LPWG	(i) King and Spanish mackerel fishery of T&T – pending acquisition of data from key neighbouring States (ii) Crevalle Jack fishery of T&T – required to be carried over (iii) The Chairperson will circulate a list of large pelagic species to allow countries to identify their important fisheries, and to confirm which fisheries should be reviewed during 2007-08
RSWG	(i) Mutton snapper fishery of Belize
SGWG	(i) Smalleye croaker fishery of Guyana (ii) Acoupa weakfish fishery of Guyana (iii) Whitemouth croaker fishery of Trinidad and Tobago (iv) Atlantic seabob fishery of Guyana and Suriname (sub-regional assessment)
SCPWG	No species identified

In addition, the following fisheries were identified by national representatives for review during the 2007-08 time period:

- (i) The queen conch and spiny lobster fisheries of Belize
- (ii) The reef fisheries of the Turks and Caicos Islands
- (iii) Red hind and triggerfish fisheries of Montserrat, following establishment of full-scale data collection program in September

The meeting was advised of the progress of several research and assessment studies that would be of interest to the CRFM scientific meetings, including: a queen conch assessment of Barbados, a socio-economic survey of the longline and reef fisheries of Barbados, the effect of pollution on fisheries in Trinidad and Tobago and other studies. The Secretariat asked the persons concerned for copies of the reports of these studies when completed.

12. Election of Working Group Chairpersons for 2007-08 time period.

The following table provides details of the nominations and elections for the position of Working Group chairperson for each of the CRFM Fisheries Resource Working Groups. These elections will be reconfirmed by the respective national fisheries administrations.

Working Group	Elected Chairperson	Nomination details
CLWG	Ms. Patricia Hubert-Medar (St. Lucia)	The first nomination was submitted by the representative from Barbados. The nomination was seconded by the representatives from Grenada and Jamaica.
LPWG	Mr. Christopher Parker (Barbados)	The first nomination was submitted by the representative from Trinidad and Tobago. The nomination was seconded by the representative from Belize.
RSWG	Ms. Kathy Lockhart (Turks and Caicos Islands)	The first nomination was submitted by the representative from Belize. The nomination was seconded by the representative from Grenada.
SGWG	Ms. Lara Ferreira (Trinidad and Tobago)	The first nomination was submitted by the representative from Suriname. The nomination was seconded by the representative from Barbados.
SCPWG	Mr. Crafton Isaacs (Grenada)	The first nomination was submitted by the representative from Belize. The nomination was seconded by the representative from St. Lucia.

13. Any other business.

No issues were discussed under this agenda item.

14. Review and adoption of meeting report.

The revised versions of 14 individual fishery (fisheries management advisory summary sections only) and Working Group Chairpersons' reports were reviewed. In respect of the wahoo report, a further amendment was requested to include the recommendation on the timing of the next assessment. In respect of Guyana's bangamary fishery report, a further amendment was requested to include a reference to the relevant WECAFC report. The first draft of the Chairman's report for RSWG was reviewed. All fishery management advisory summaries and Chairpersons' reports, except the RSWG Chairperson's report, were adopted with agreed amendments. Sections of the plenary session report were also reviewed.

It was agreed to adopt the RSWG Chair's report and the plenary session report by email. The full fishery reports, that would include section 1.8, would be completed and submitted to the Secretariat as soon as possible.

15. Adjournment.

In closing, the Meeting Chairperson, Mr. Ryan, thanked the Secretariat for its hard work and also for assisting with the chairing of sessions, as required. The contributions made by fisheries officers, consultants and other participants in ensuring a successful meeting were also acknowledged. Mr. Ryan also took the opportunity to thank FAO for participating in the Meeting and for its contribution to the discussions.

The Meeting was adjourned at 4.45 p.m.

APPENDICES

Appendix 1: Meeting Agenda

CRFM THIRD ANNUAL SCIENTIFIC MEETING
Fisheries Division, Kingstown, St. Vincent and the Grenadines

I. Training sessions in statistics and catch rate standardization: 16 July 2007

II. Individual Resource Working Group Sessions: 17– 23 July 2007

Completion of selected fisheries analyses and assessments and Working Group reports.

III. Formal plenary sessions: 24 – 26 July 2006

1. Opening of the meeting.
2. Election of chairperson.
3. Adoption of meeting agenda and meeting arrangements.
4. Introduction of participants.
5. Presentation of national (country) reports.
6. Review of Report of the Second Meeting of the CRFM Ad Hoc Working Group on Methods.
7. 2007 reports of the CRFM Fish Resource Working Groups (listed in alphabetical order):
   - i Conch and Lobster Resource Working Group (CLWG);
   - ii Large Pelagic Fish Resource Working Group (LPWG);
   - iii Reef and Slope Fish Resource Working Group (RSWG);
   - iv Shrimp and Groundfish Working Group (SGWG);
   - v Small Coastal Pelagic Fish Resource Working Group (SCPWG).
8. Review and discussion of Working Group recommendations to improve statistics and research inputs.
9. Special lectures:
   - i IMA fish growth studies
   - ii Socio-economic monitoring by Caribbean authorities
   - iii CARICOM's Common Fisheries Policy and Regime
10. 2007 Network partnership activities
    - i Global Bycatch Assessment Project
    - ii UNU-FTP short-term training arrangement
11. Identification of assessment needs and Working Group Rapporteurs for 2007-08 period.
12. Election of Working Group Chairpersons for 2007-08 period.
13. Any other business
14. Review and adoption of meeting report.
15. Adjournment.

Appendix 2: List of Participants

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17-26 July 2007, Kingstown, St. Vincent & the Grenadines

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Appendix 3: Report of the Conch and Lobster Resource Working Group

Chairman: Patricia Hubert-Medar
Species Rapporteurs: Anginette Murray (Jamaica); Patricia Hubert-Medar (St. Lucia); and Kathy Lockhart (Turks and Caicos Islands)
Consultant: Paul Medley PhD.

A. OVERVIEW

At the Second Annual CRFM Scientific Meeting held in 2006, it was agreed that the Conch and Lobster Working Group should continue conducting assessments on the Lobster and Conch fisheries for St. Lucia, Jamaica, Bahamas and Turks and Caicos. The species rapporteur for the Bahamas, Mr. Lester Gittens was selected as Chairman for the third annual CRFM scientific meeting, but was not able to attend this meeting. As a result a new chairperson was nominated in the person of Patricia Hubert-Medar. Mrs. Anginette Murray replaced Mrs. June Masters as the species rapporteur for the lobster fishery in Jamaica.

One of the recommendations at the Second Annual CRFM Scientific Meeting was for Jamaica to conduct two visual surveys of the conch on Pedro banks. It was reported that one such assessment was conducted in January 2007 and the other is proposed to be conducted in September of the same year. TCI was to provide updates for the conch fishery including local consumption.

Dr. Paul Medley was the consultant assigned to the Conch and Lobster working group. He worked along with: Mrs. Patricia Hubert-Medar whose assessment was based on the St. Lucia conch fishery, Mrs. Anginette Murray who worked on the lobster fishery in Jamaica and Mrs. Kathy Lockhart who updated the conch and lobster assessments for the TCI.

The terms of reference for the Conch and Lobster Working Group was:

- To determine the TAC for the TCI lobster.
- To update the assessment for the TCI conch including local consumption.
- Feasibility to carry out a stock assessment on St. Lucia conch. It was realized that a stock assessment was possible, so it was undertaken.
- Conduct an exploratory analysis of the Jamaica lobster catch and effort data, to develop a strategy to conduct a stock assessment including identifying research priorities for Jamaica

Assessments
No assessment was conducted on the conch and lobster fishery for the Bahamas since the species rapporteur, Mr. Gittens was absent.

Conch
A simple biomass dynamics (Schaefer) model was fitted to a CPUE index using the available catch estimates. The additional "prior" information on the population parameters (rate of increase and unexploited stock size) was included as mathematical probability functions based on assumptions and errors in the estimates from the Caicos Bank and Pedro Bank assessments. The

model was fitted using a Bayesian fitting method that combines the information in the prior and the observations to produce a “posterior” probability for the state of the stock, MSY, replacement yield and other indicators of interest. The model explains the observations well, as indicated by the close fit between the observed and expected CPUE index. However, wide ranges of parameter estimates explain the observations equally well unless additional information on the productivity of this species elsewhere is incorporated. The R^2 statistic indicates that most variation in the CPUE index (i.e. the downward trend) can be explained by the model. However results depend upon the prior information being reasonable. The results were considered sufficiently reliable for adaptive management action.

The Caicos Bank TAC recommendation was updated for the 2007-2008 season based on new data and local consumption data. Including local consumption improved the assessment and this model has now become the standard for management advice.

Lobster

For the TCI, the assessment was based on a recruitment index estimated from the August catch and effort data. The recruitment index is then used to fit the annual catch and effort time series 1974-2006. Once assessed a minimum Total Allowable Catch (TAC) was determined based on the lowest observed recruitment using a standard spawners-per-recruit reference point (SPR40% for 83mm CL; FAO 2006) of approximately 650,000 lbs. A final TAC is then intended to be determined once a recruitment index is made available from the August catch and effort data in November, and the TAC duly topped up with the additional recruits.

Due to insufficient available data for the Jamaica lobster fishery, a stock assessment was not carried out. However, exploratory data sought to identify any seasonal patterns in the CPUE indices as preliminary to developing a recruitment index and monitor trends in mean size. In an attempt to identify and establish a recruitment index, the available catch and effort data submitted for period 1995-2007 were examined. The mean CPUE by month suggests that there may be a decline in catch rate from June to December. This may be the result of recruitment occurring during the closed season increasing the stock size at that time. However, the data are very noisy and sparse so any further attempt to separate out different effects was found to be impossible.

Recommendations

- Rapporteurs should be well advised during the inter-sessional period of the exact format and type of data requested for assessment prior to the scientific meetings.

- National governments should improve resources such as man power and or finance to collect social and economic data and other relevant data pertinent to assessments.

- Advice is needed as to what data can be collected for the purpose of conducting socio-economic assessments.

- An Economist should be invited to the working group meeting and advise participants with regards to data collection.

- It is recommended that Jamaica data collection be raised as a priority so that better coverage can be conducted.

- The CRFM secretariat needs to incorporate a consultant with economic and social experience to deal with the economic aspect of the assessments at the next scientific meeting.

Stock Assessments for 2008

The working group terms of reference should include in 2008:

- Reassessment of the TCI lobster TAC,
- Reassessment of the St. Lucia conch,
- Jamaica lobster assessment, conditional on the provision of new data,
- Assessment of Bahamas lobster

Other countries conch fisheries will also be checked to see whether several assessments could be conducted based on the method being developed for St. Lucia.

B. FISHERIES REPORTS

1.0 The Spiny Lobster (*Panulirus argus*) Fishery of the Turks and Caicos Islands

1.1 Management Objectives

1. Ensure that the catch in any one year does not exceed the MSY.
2. Improve on net exchange earnings from the lobster fishery.
3. Promote management at the regional level in order to improve the effectiveness in managing the lobster fishery of the Turks and Caicos Islands.
4. Improve our understanding of the spiny lobster stock status in the waters of the TCI.

1.2 Status of Stocks

Lobster landings continued to fluctuate, reaching a peak of 590 MT (1,312,795 lbs.) in 1992/1993 fishing season followed by a steady decline to an all time low of 320 MT (400,375 lbs.) in 2002/2003 fishing season. This decline in catch was attributed to many factors, including low larval retention/recruitment to the TCI fishery during the previous fishing years and/or the harvesting of illegal stock size (Medley & Ninnes, 1997; Bethel *et al*., 2000).

While the spawning stock biomass can be estimated, a minimum spawning stock size cannot be determined at this time due to the lack of a reliable stock-recruitment relationship for spiny lobster. Instead, a reference point of $SPR_{40\%}$ (a fishing mortality which gives 40% of the unexploited spawning stock under constant recruitment) was used which has been proposed for the region (FAO, 2006). This suggests that overfishing has occurred in the past, and that, overall the stock has been fully exploited since 1977. In 2005 and 2006 overfishing was occurring. The information is sufficient at this time to establish a total allowable catch.

1.3 Management Advice

In order for management to meet the objectives, a suitable control on fishing mortality needs to be established. A total allowable catch (TAC) based on a Maximum Sustainable Yield (MSY) reference point has been identified as the most suitable control. The following is the recommended advice:

- Set a minimum TAC in May, based on the lowest observed recruitment index, at 650,000 lbs whole landed lobster.
- Conduct an annual stock assessment in November updated by the estimated recruitment using the August data. The TAC would then be topped up based on the additional recruits.
- At least two persons in the department need to be able to carry out the annual assessment to allow the TAC top-up.

This harvest rule would allow the fishery to maintain the economic productivity each year for full-time fishers by avoiding extreme fluctuations in catches and reducing the influx of part-time fishers.

1.4 Statistics and Research Recommendations

1.4.1. Data Quality

Catch and effort data are collected from the local processing plants. The data are of good quality, but have a few areas lacking information, such as undocumented August catch for years 1997-

2002. Morphometric parameters have been collected from 1989-1998 and then again collected from 2005-present.

1.4.2. Research

- Conduct an annual recruitment assessment, set a minimum TAC (in May) and as well as allowing the TAC to be topped up (in November), this will guard against changes in the method of fishing which could invalidate the recruitment index.
- Collection of indices such as juvenile abundance in nursery areas, and adult abundance in fishing areas.
- Continue collection of length composition and other biological data of landed lobsters. A regional fishing mortality (F) was determined at the FAO WECAFC Lobster Workshop in Merida. A growth model specific to the Caicos Bank may be used to update this reference point.

1.5 Stock Assessment Summary

The objective of the assessment was to propose a total allowable catch for the stock. This involved updating the current stock assessment with the available data and then identifying a suitable harvest rule for calculating a TAC for this stock.

The previous stock assessment was updated (FAO WECAFC 2006). The assessment is based on a recruitment index estimated from the August catch and effort data. The recruitment index is then used to fit the annual catch and effort time series 1974-2006. The time series of data was extended in this assessment, including the years 1974-1976 and 2006 (Figure 1).

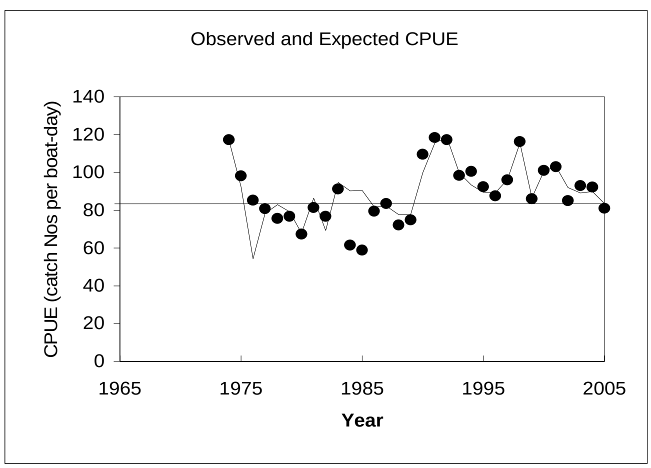


Figure 1: Observed and expected CPUE. The CPUE was used as an index of abundance to fit the population model. The model fits the data well with the exception of years 1976, 1984 and 1985 when catch and effort data recording was poor.

A minimum Total Allowable Catch (TAC) was determined based on the lowest observed recruitment using a standard spawners-per-recruit reference point (SPR40% for 83mm CL; FAO 2006) of approximately 650,000 lbs. A final TAC is then calculated using the new recruits and the mature stock at the beginning of each year based on the SPR 40% fishing mortality, which has been proposed for the region (at the FAO WECAF Workshop in Merida; FAO 2006).
As can be observed over the years, if this type of management was in place the economic returns to fulltime fishers would have been more consistently achieved, while reducing the number of

part-time fishers. The annual assessment allows for the minimum TAC to be surpassed based on the recruits for that year and therefore is precautionary (Figure 2).

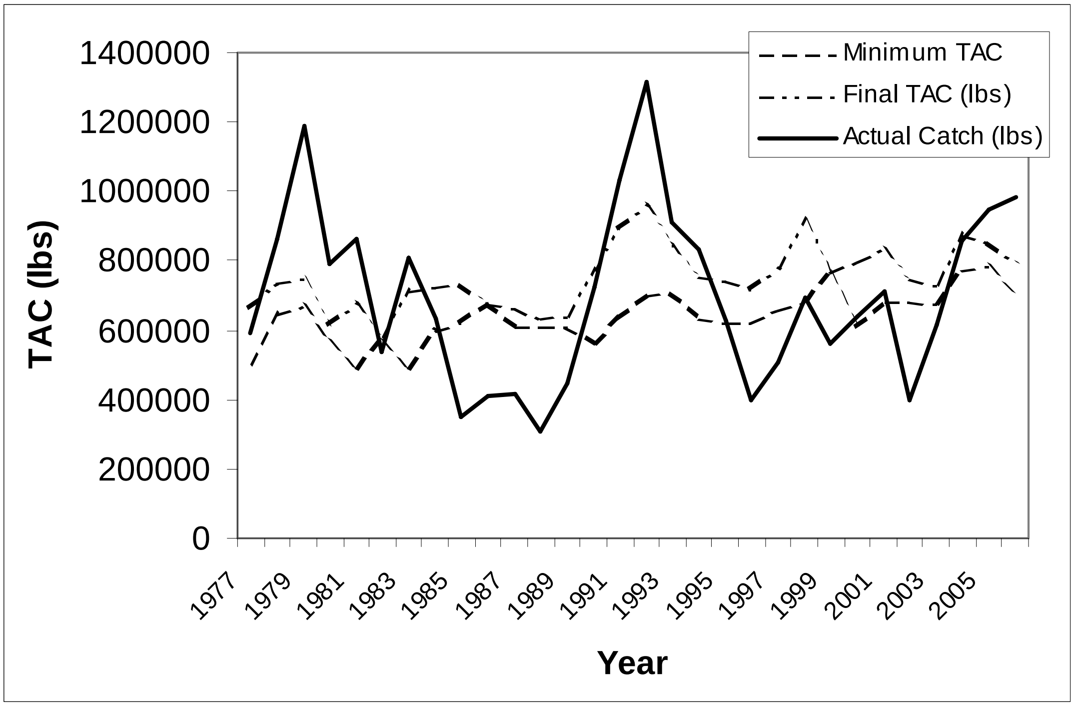


Figure 2: If the harvest rule described had been used to set the TAC in each year, the high levels of harvest observed in the past would have been capped. It might be expected that more stock would have carried over between years smoothing out the landings and possibly enhancing recruitment through the years.

1.6 Special Comments

None.

1.7 Policy Summary

Although protection of fisheries resources is implicit in the overall development strategy of the TCI, the importance of the fisheries sector in present and future development and the fragility of the resource base warrant the establishment of a specific policy for the industry.

The Fisheries Policy aims to ensure the sustainable use of the living marine resources and ecosystems through increased cooperation and collaboration with all the stakeholders for the improved welfare of the people of the TCI.

Inclusive to the policy is the current functioning stock assessment to determine a MSY for the Queen Conch. With this effective harvest strategy, it seems apparent that determining a TAC for the spiny lobster population could also be just as effective. Often times it is suggested that effort controls such as restriction of the fishery be the management control. However, it is socially unacceptable to place effort restrictions, so harvest strategy such as TAC would again be the most effective management tool for the TCI government.

1.8 Scientific Assessments

1.8.1. Background or Description of the Fishery

The Turks and Caicos Islands (TCI) continues to fish commercially for spiny lobster (*Panulirus argus*) on both the Turks and the Caicos Banks. The majority of the catch is landed at any one of five processing plants, where they are prepared for export to international markets, mainly the USA.

Spiny Lobster catches are recorded as pounds daily at each of the five main processing facilities. Lobster is landed whole, although it is exported most often as frozen tail. Local fishermen leave the dock in small retrofitted boats (fiberglass with 75-105 hp outboard engines) between 7:00 and 8:00 am and return between 4:00 and 5:00 pm. While out to sea the lobster is collected by free diving up to 20 meters in depth depending on the capability of fishermen and location. Each boat carries a boat driver (keep-up) and 2 divers.

1.8.2. Overall Assessment Objectives

The objective of the assessment is to determine a minimum Total Allowable Catch (TAC) based on the lowest recruitment index of 103 and a "top up" to the TAC through an annual assessment based on a regional fishing mortality (f). Setting a TAC could aid in maintaining the economic productivity of the full-time fishers.

1.8.3. Data Used

Name	Description
Catch and Effort Data	The catch landed by each boat is recorded and submitted via processing facility. Effort of each boat is recorded via boat-days (boats go out for single days). Information is also collected on the number of fishers on the boat to provide man-days. Data for the assessment ranges from the 1970's to current years.
Morphometric parameters	During landing catch is sub-sampled to determine the morphometric parameters including: weight, carapace length, sex and breeding information (tar or berried). Data were collected from 1989-1998 and then again from 2005-present.

1.8.4. Assessment 1

<u>1.8.4.1 Objective</u>

The main objective is to determine an annual Total Allowable Catch for the Spiny Lobster stocks with a minimum TAC based on the lowest recruitment of 103, and a maximum TAC based on a regional fishing mortality (f).

<u>1.8.4.2 Method</u>

An update of the recruitment model for spiny lobster (see Medley and Ninnes 1997 for a detailed description) was conducted after the Merida FAO WECAFC Workshop. The model requires the total catch and at least a sample of the catch and effort data in each season as well as an index of recruitment. The index, which needs to be proportional to the number of recruits, has been calculated using the August (start of season) daily catch and effort data. August daily catch and effort data for calculating the index was available for 1977-1996 and 2003-2006. Based on the following recruitment index model:

$$N_{s+1} = (N_s - C_s)\, e^{-M} + \lambda\, I_{s+1}$$

N_s = population size of all lobsters at the start of season s, C_s = total landing in numbers of lobster in season s, and M= natural mortality (per year), I_s = recruitment index, λ = parameter converting the recruitment index to a total recruitment number.

The model primarily works with lobster numbers rather than weight. Conversion from weight to numbers was carried out using average individual weight estimated from morphometric data. New length and weight data for 2005-2006 were available for the most recent years. A conversion based on 2005-present morphometric data provided the following carapace length to total weight conversion (Figure 3):

	Coefficients	*Standard Error*
Intercept	-5.50871	0.076794
X Variable 1	2.651771	0.016815

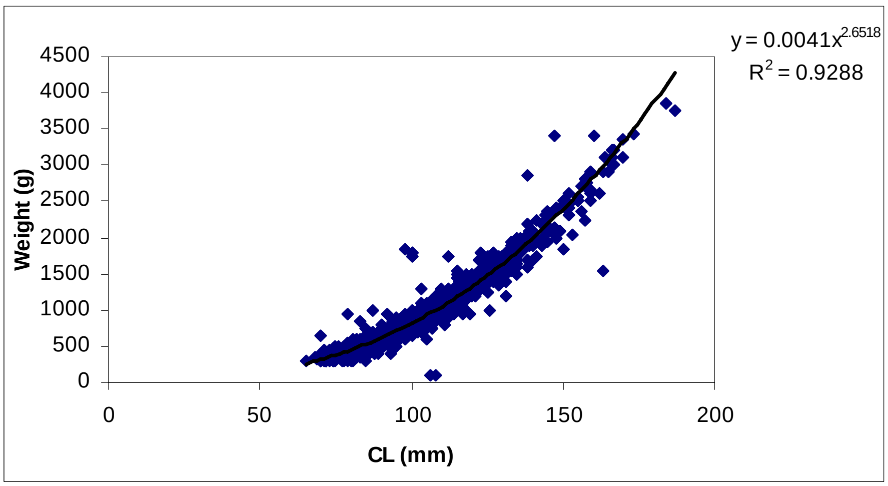


Figure 3: Carapace length to total weight conversion

Where daily August data were available, the recruitment index was estimated as the initial population size parameter in the fixed recruitment depletion model (see Medley and Ninnes 1997). The recruitment index for the years where no August data were available, were set at the average of the estimated indices.

Fishing mortality was calculated using the annual population model above and the catch equation as follows:

$$C = (F/(F+M))\ (N_s - N_{s+1})$$

Where C = catch in numbers, F= fishing mortality, M = natural mortality, N_s = the population size in season s, where N_{s+1} does not include the new recruits of season s+1. This equation was re-arranged to solve for F.

1.8.4.3 Results

The estimated recruitment indices have fluctuated over the years. However, with information unavailable from 1997 through 2002, interpretation of a long-term trend in recruitment is difficult (Figure 4). The R^2 statistic for the 2005 and 2006 of the daily catch per unit effort (CPUE) ranged from above 0.7 to below 0.4 (Figure 5) indicating a questionable fit for the 2006 year.

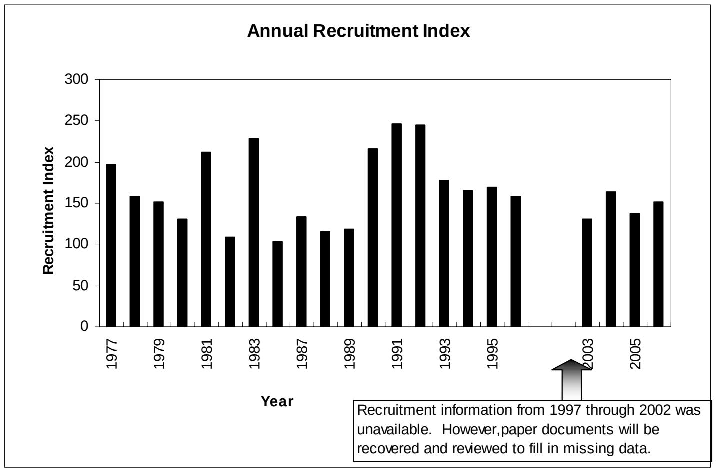
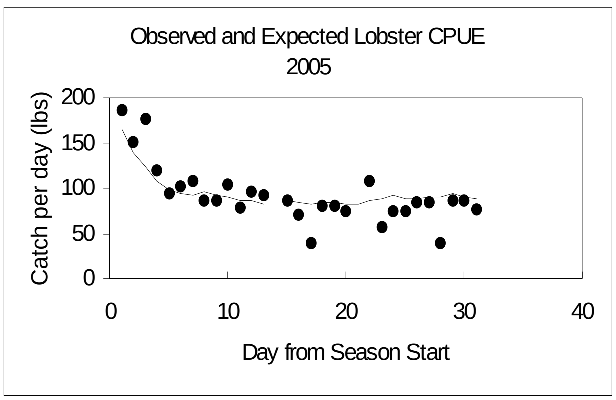


Figure 4: Annual Recruitment Index based on daily landing at the start of the season (August). The Model excludes unavailable data from 1997 through 2002.



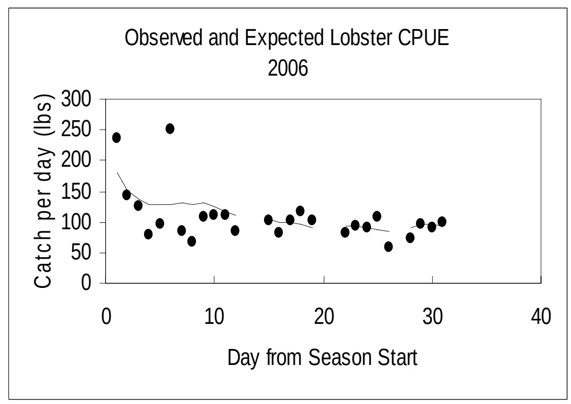
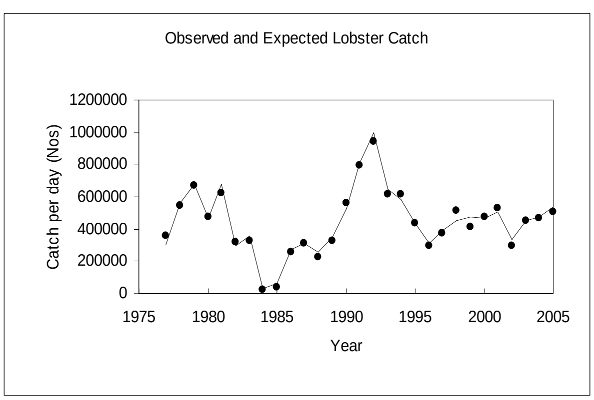


Figure 5: 2005 and 2006 Fit of Observed and Expected Catch per Unit Effort (CPUE) (R^2=0.70 and R^2=0.37 respectively).

Based on the recruitment model, a population model from 1977 through 2006 was conducted. The model produced a "good fit" to the data (Figures 6 & 7).



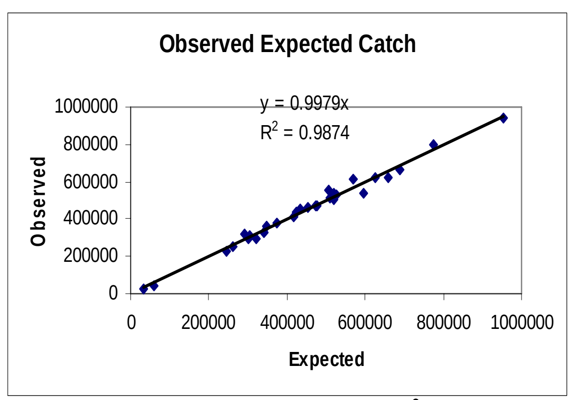
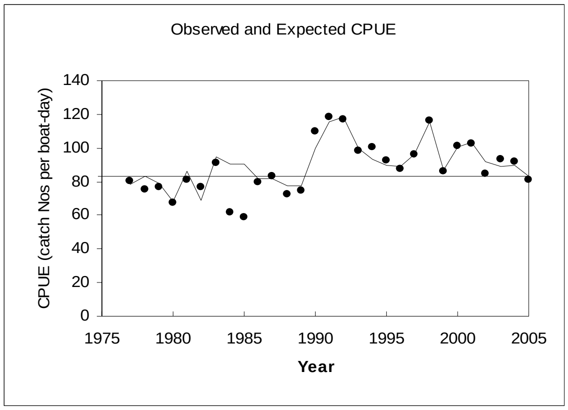


Figure 6: Population Model based in Number of Lobster with a Correlation of Catch (R^2=0.9874).



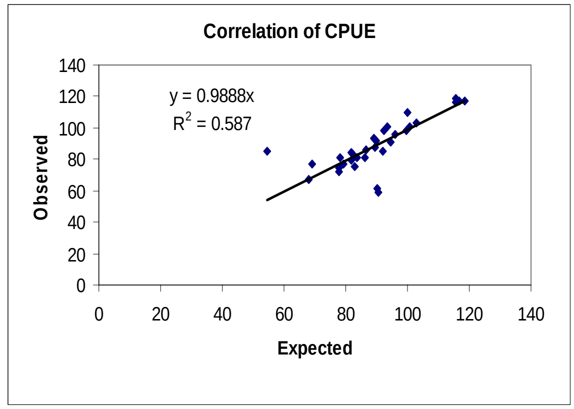


Figure 7: Observed vs. Expected CPUE based on Population Model with a Correlation (R^2=0.587).

The catch increased from approximately 181.4 MT (400,000 lbs) in 2002 to 446.4 MT (984,000 lbs) in 2006. This increase is not as noticeable in Figure 6, because catch is in numbers. The average individual weight estimated for 2006 was found to be relatively high (0.845 kg (1.81lbs)/individual), suggesting that gains in catches have been supported by not only better recruitment, but landing larger lobster. However, many years' size estimates are based on weight estimates from other years and there are significant gaps in the average weight data, splitting up the cause for the increase in yield between recruitment and growth uncertainty. It is possible to infer that stricter enforcement of the minimum size regulation has made a significant contribution to the improvement in yield.

Fishing mortality has fluctuated over the years from 1977 until present (Figure 8). However in the 1980s the TCI experienced a lower fishing mortality (F) as fishers left for construction jobs in the Bahamas which became available during the 1980s. In the 1990s, economics of the fishery allowed for better wages and therefore fishing effort (mortality) increased, but under better management control.

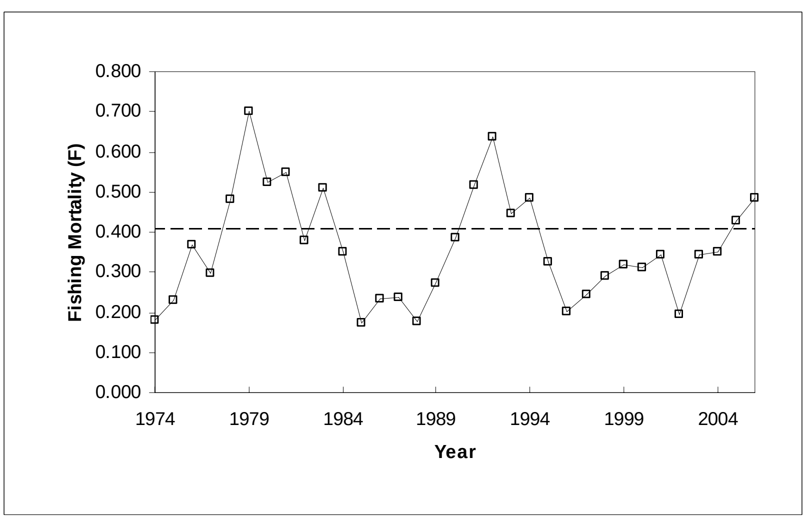


Figure 8: Fishing mortality based on a catch model.

Since 1995, the fishing mortality has remained relatively stable at approximately 0.41 $year^{-1}$ (Figure 8) It is likely that stricter management controls not only promoted landing larger individuals, but has also aided in stabilizing fishing mortality.

At the FAO WECAFC Lobster Workshop in Merida 2006, a regional fishing mortality was determined. A Spawners per Recruit was set for 83 mm carapace length of 40%. A minimum TAC was determined at approximately 650,000 lbs. using this 40% fishing morality and the lowest recruitment index of 103.

However, based on potential economic returns and landing a "top up" annual assessment was also conducted. This assessment allows for the minimum TAC to be surpassed based on the recruits for that year. Figure 9 shows the past as if it were inclusive of the minimum TAC, the final TAC including the "top up" and the Actual landings.

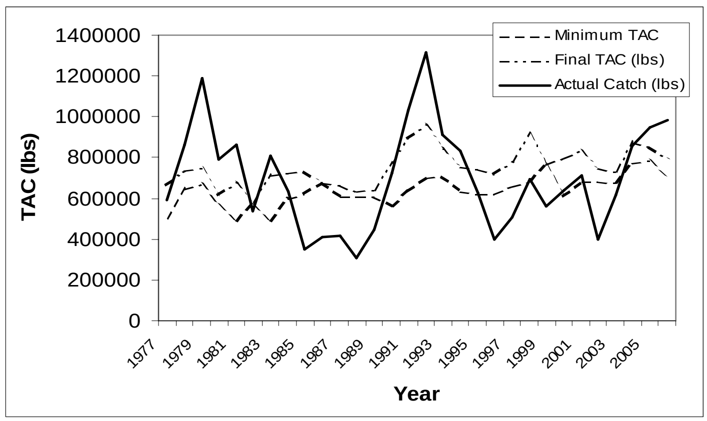


Figure 9: Annual levels of minimum TAC and the final TAC including the "top up". Actual landings are shown as the solid line.

Further improvements in the model and assessment will become available with the aid of a fishery independent recruitment index. As well as allowing the prediction of recruitment up to a year in advance, the index will also be made independent of prospective management controls. There is a concern that better enforcement of the minimum size regulation will undermine the use of the daily August catch and effort as a recruitment index.

It is important that size composition, and in particular, the average weight is well estimated each season. This will allow the model to separate the effects of recruitment (which may be largely outside the control of management) and that of size (which can be controlled by management).

1.8.4.4 Discussion

According to the management objectives of the Turks and Caicos Islands, this meeting allowed for a large step to be addressed. Throughout the region lobster are not significantly managed and the TCI wanted to take steps to manage and attain sustainability to the fishery and economics for the future. The results that have been obtained in this meeting have allowed for the TCI to take steps in determining a minimum Total Allowable Catch (TAC) of 650,000 lbs. whole landed lobster. Without the choice of effort controls, the TCI needed to review a potential use of a TAC. Without detriment to the species and now significant impact to the social and economic patterns of the fishers, the TCI can observe potential impacts of setting a TAC inclusive of the "top up" that is calculated, based on the SPR40% reference point.

A TAC can allow for the fishery to be fished while maintaining economic productivity to the full-time fishers. It also would allow for the fishery to be managed in a regional manner based on regional fishing mortality.

1.9 References

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Pardee, M. & Corsaut, J. (2003). Report on Preliminary Findings of the TCI Lobster Recruitment Study. Unpublished.

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2.0 The Queen Conch (*Strombus gigas*) Fishery of the Turks and Caicos Islands

2.1 Management Objectives

- To ensure that the catch does not exceed sustainable levels or a predetermined reference point (e.g. MSY).
- To maintain effort levels in the queen conch fishery at or below the corresponding level required to obtain the target reference point.

2.2 Status of Stocks

According to the assessment conducted at the Second and Third Scientific Meetings for CRFM, catch rates are operating at a constant level, which imply that the stocks are operating at optimum levels, with a biomass at 56% of the unexploited biomass.

2.3 Management Advice

Advice for management to meet the management objectives are as follows:

- Continue to assess the conch stock yearly, based on catch, effort and local consumption data to determine current status of the conch population relative to the biomass and fishing effort that produce maximum sustainable yield (MSY)
- Total Allowable Catch is effectively working with the closed season and effort controls.

2.4 Statistics and Research Recommendations

2.4.1. Data Quality

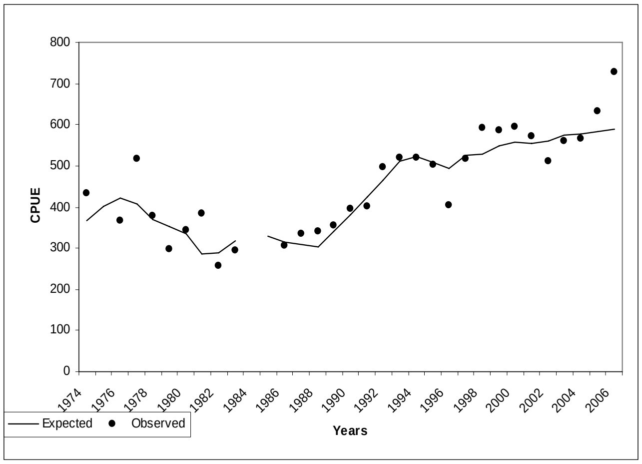
Catch and effort data are collected from the local processing plants. The data are of good quality, but have a few areas lacking information, such as illegal harvest. The DECR completed a local consumption survey of Queen conch in 2005 and has updated the assessment. However, there was an increase in estimated population based on immigrant migration and it was therefore suggested that the assessment be conducted to include local consumption.

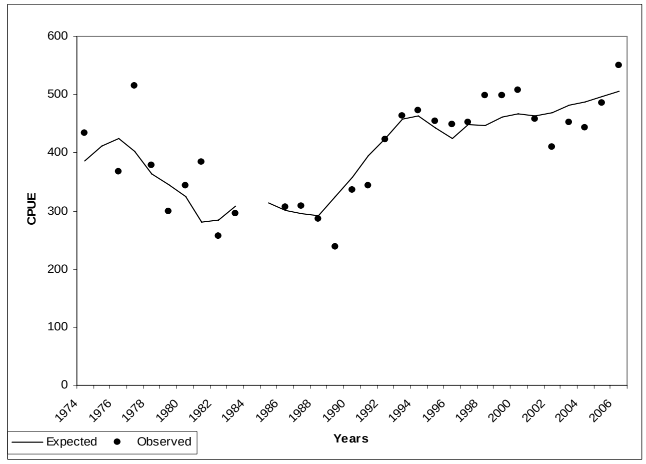
2.4.2. Research

- Conduct a visual survey to determine the abundance of conch.
- Work with the Department of Economics and Planning to study economic aspects of the fishery before the end of 2008.
- Examine possibilities of hiring an economist to provide understanding of the economic pros and cons for the conch fishery.
- Provide additional funding for research to add parameters to the current stock assessment model (i.e. conch shell length versus shell lip thickness, additional visual surveys, local consumption survey, population census, fisher information).

2.5 Stock Assessment Summary

The assessment used available catch and effort data to determine the Maximum Sustainable Yield (MSY), the effort necessary to obtain MSY, the virgin (unfished) biomass level, and the status of the fishery relative to conditions generating MSY (i.e., current effort and current biomass relative to the levels producing MSY). A Schaefer model was re-produced that showed a high correlation of more than 60% between observed and expected catch rates (CPUE).





Stock Assessment Utilizing Local Consumption Data

p = 0.3486645
r = 0.432024217
K = 19050655
q = 0.00006
Sum of Squares = 9.10E+11

Stock Assessment Utilizing ONLY Catch and Effort Data

p = 0.450038232
r = 0.387940512
K = 17806838
q = 0.00005
Sum of Squares = 1.369E+12

Diagram A. Observed vs. Expected CPUE for two models fitted using Excel's Solver.

Sensitivity analysis demonstrates the following:

Assessment with recorded catch & effort only	1,726,998 lbs. 4032.25 boat-days 60% 67.6%	MSY f_{MSY} $B/B_{Unexploited}$ Effort as % of f_{MSY}	* Quota for 2007-2008 1,416,139 lbs. (precautionary approach for local consumption 82%)
Assessment with local consumption included in the catch	2,057,586 lbs. 3922.74 boat-days 56% 69.5%	MSY f_{MSY} $B/B_{Unexploited}$ Effort as % of f_{MSY}	* Quota for 2007-2008(-600,000 lbs. local consumption) 1,457,586 lbs.

**Quota for 2007-2008 is based on local consumption of conch on the current estimated population of more than 34,000 individuals.*

Sensitivity analysis indicates that the local consumption information does increase the MSY, but it does not greatly influence the effort necessary to achieve MSY. If the TCI was to set a quota for the fishery based on the MSY from catch and effort data only, it would be operating within 1.9% of the most conservative MSY. However, if the assessment is based on the addition of local consumption, the TCI government must remember that approximately 600,000 lbs. of conch would be consumed locally and must be removed from the total MSY before the quota allocation for export.

2.6 Special Comments

This year's assessment was an update of the 2006 CRFM assessment. The analysis was to re-evaluate the local consumption because of an estimated increase in local population. The method of analysis remains the same as the last assessment. However, the impact of local consumption is expected to increase because of the increase in human population.

2.7 Policy Summary

Although protection of fisheries resources is implicit in the overall development strategy of the TCI, the importance of the fisheries sector in present and future development and the fragility of the resource base warrant the establishment of a specific policy for the industry.

The Fisheries Policy aims to ensure the sustainable use of the living marine resources and ecosystems through increased cooperation and collaboration with all the stakeholders for the improved welfare of the people of the TCI.

Inclusive within the policy is the functioning stock assessment that determines a MSY for the Queen Conch. With this effective harvest strategy in place, the TCI has an effective management tool. With socially unacceptable management controls such as effort control, setting a TAC based on the MSY is an effective management tool.

In order to make sure that the TCI is continually allowed to freely trade the queen conch species, it must take necessary steps to become a signatory to the CITES Convention (i.e. complete the draft Endangered Species Bill and provide permanent legislation for mandated Scientific and Management Authorities).

2.8 Scientific Assessments

2.8.1. Background or Description of the Fishery

Queen conch catches are recorded as pounds daily at each of the five main processing facilities. Conch is landed whole without a shell, although they are exported as "clean white meat". Local fishermen leave the dock in small retrofitted boats (fiberglass with 75-105 hp outboard engines) between 7:00 and 8:00 am and return between 4:00 and 5:00 pm. While out to sea the conch are collected by free diving up to 20 meters in depth depending on the capability of fishermen and location of conch. Each boat carries a boat driver (keep-up and knocker) and 1-2 divers.

The conch fishery works in connection with the lobster fishery during lobster season. Divers switch between species depending on availability. The conch fishery has been in the TCI since the 1800's with trade between Haiti and the TCI. However, when freezer technology arrived in the TCI the fishery expanded its exportation. Since the 1990's the TCI has been landing on average 1.6 million lbs. of conch yearly and exports approximately 600,000 lbs. of clean conch meat each year.

2.8.2. Overall Assessment Objectives

The objective of the assessment is to predict a Maximum Sustainable Yield (MSY) for the TCI Queen Conch Stocks. It is expected that the MSY would not be surpassed by the TCI Government and would rather take a precautionary approach to better protect the available stocks.

2.8.3. Data Used

Name	Description
Catch and Effort Data	The catch landed by each boat is recorded and submitted via processing facility to the DECR. Most catch is recorded this way. Effort of each boat is recorded via boat-days (boats go out for single days). Information is also collected on the number of fishers on the boat to provide man-days. The catch data extends back to 1887 with effort being collected since 1970's.
Local Consumption Data	A survey was conducted in 2004-2005 to determine the consumption of queen conch per person. The survey included age, sex, nationality, location, quantity of consumption and frequency. Vital statistics (2001 Census) provided the population statistics.

2.8.4. Assessment 1

2.8.4.1 Objective

The main objective is to determine a Maximum Sustainable Yield for the current Queen Conch stocks. A model has been utilized for the past 10+ years, but needs to be recalculated yearly. There is a second objective, which was to determine if add local consumption information greatly influences the model.

2.8.4.2 Method

Available catch, effort and Catch per Unit effort (CPUE) data were arranged by yearly totals in an Excel spreadsheet format. The data utilized were from 1974 to the year 2003. The assessment was to include up until the 2005-2006 fishing season. However, when sorting the data, it was discovered that some discrepancies occurred and the data had to be corrected. Data for 2004-2005 were not available at the workshop. A Schaefer model was used to estimate the Maximum Sustainable Yield (MSY), based on the catch and effort data collected. The model fitted was:

$$B_{t+1} = B_t + rB_t\,(1 - B_t / K) - Y$$

$$\text{Predicted CPUE}_t = q\,B^*_t$$

where

B_t = Total Biomass at the start of year t (lbs.)

r = Rate of increase yr^{-1} (the stock growth rate)

K = Maximum biomass at the carrying capacity of the environment (lbs)

Y = Total yield or catch (lbs)

p = Initial stock size as a proportion of K

q = Catchability coeffient (assumed constant)

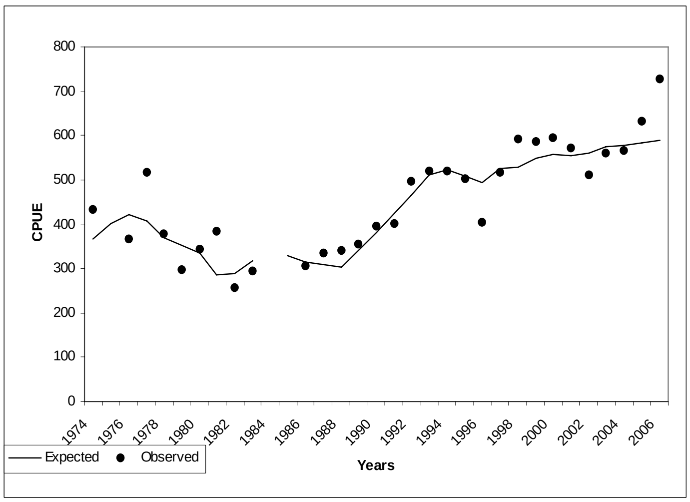
f = Effort of fishermen (in man-days)

The Schaefer model utilized catch production. Population size allowed for an expected catch to be determined yearly. The expected catch divided by the effort produced an expected CPUE. The sum of squared errors is determined by comparing the expected and observed CPUE. The sum of squared errors is minimized with the solver add-in program within Excel.

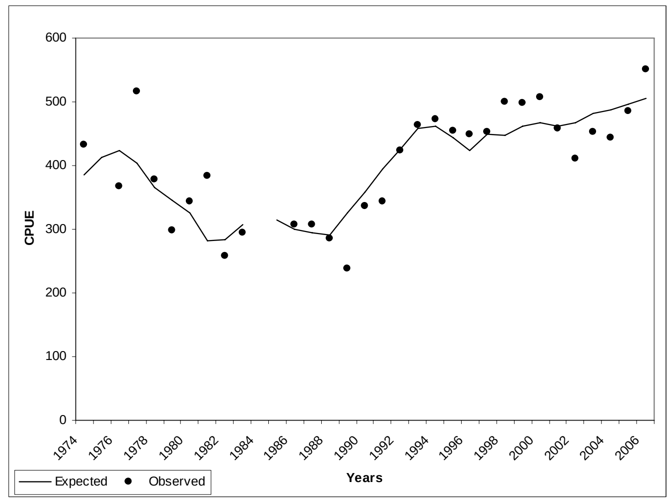
Finally, the same Schaefer model was utilized with additional information from local consumption. However, local consumption was determined via a survey that had been conducted in 2004-2005. The consumption index from that year was then adjusted to the population for previous years. (TCI Census 2001)

2.8.4.3 Results

The model produced an MSY that had been fairly consistent over the past few years. When local consumption information was introduced to the model, a better fit to the model was found (Diagrams A & B).

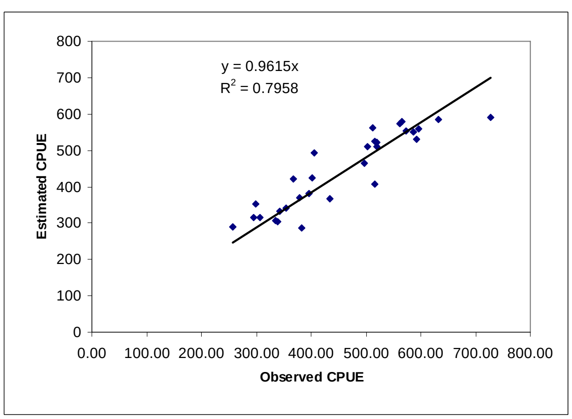


Stock Assessment Utilizing Local Consumption Data

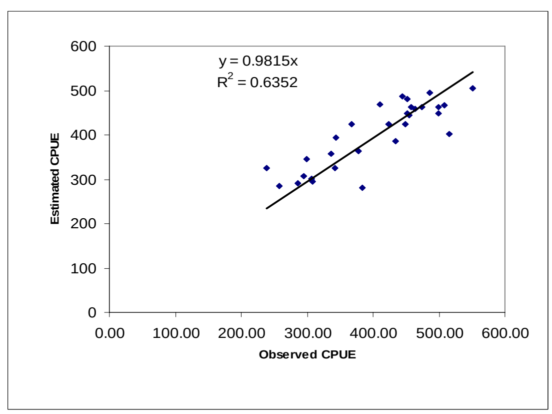


Stock Assessment Utilizing ONLY Catch and Effort Data

Diagram A. Observed vs. expected CPUE for two models fitted using Excel's Solver. The model to the left has local consumption model added to the recorded catch while the model to the right does not include local consumption.



Correlation Utilizing Local Consumption Data



Correlation Utilizing ONLY Catch and Effort Data

Diagram B. Observed vs. expected CPUE with regression.

Sensitivity was then considered between the two analyses. The following was determined:

Assessment with recorded catch & effort only	1,726,998 lbs. 4032.25 boat-days 60% 67.6%	MSY f_{MSY} B/B_{Vigrin} Effort as % of f_{MSY}	*Quota for 2007-2008 1,416,139 lbs. (precautionary approach for local consumption 82%)
Assessment with local consumption included in the catch	2,057,586 lbs. 3922.74 boat-days 56% 69.5%	MSY f_{MSY} B/B_{Vigrin} Effort as % of f_{MSY}	*Quota for 2007-2008 1,457,586 lbs. (-600,000 lbs. local consumption)

**Quota for 2007-2008 is based on local consumption of conch on the current estimated population of more than 34,000 individuals.*

2.8.4.4 Discussion

The Turks and Caicos Islands updated analysis of the conch assessment for the 2007-2008 fishing season. During this forum the TCI updated its Schaefer model to fit the data and provide the 2007-2008 stock biomass and fishing effort relative to the MSY and F_{MSY}, respectively.

During the assessment, the TCI re-evaluated the potential of local consumption. According to the population statistics, the population in the TCI is estimated to have almost doubled from the 2001 census from approximately 19,000 to more than 34,000 individuals. The local consumption is based on the 2004-2005 consumption survey and the estimated population statistics generated by the Department of Economics and Planning. With the estimated increase in population there would be an expected increase in landings for local consumption.

The two assessments provided results that were again similar in nature. The effort at MSY (f_{MSY}) was within 2.5% of each other. The assessments suggest that effort would remain consistent if you fish for local consumption or not.

During the assessments it was determined that the model including local consumption provided a better fit to the data. However, after the MSY is determined from this assessment, a local consumption figure must be removed before allocation of the export quota. The assessment not inclusive of local consumption must determine the allocation for local consumption after MSY

2.8.5 Management

The Lobster and Conch Working Group suggested the following for the Turks and Caicos Islands (TCI):

Continue to assess the conch stock yearly, based on catch, effort and local consumption data to determine current status of the conch population relative to the biomass and fishing effort that produce maximum sustainable yield (MSY)

TAC is currently working with the closed season and controls.

2.9 References

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3.0 The Queen Conch (*Strombus gigas*) Fishery of St. Lucia

3.1 Management Objectives

The management objective for this fishery is to ensure sustainable use of the stocks and to rebuild the stocks, particularly in the nearshore area.

3.2 Status of the Stock

The stock assessment indicated that the St. Lucia conch stock is overfished, but that overfishing is probably not occurring (Table 1).

This study is consistent with the conclusion based on a study of the biological data collected during 1996-1998, which indicated that the nearshore fishery was over exploited. However, the assessment also provides a target, to increase the catch rate to be above the MSY level.

Table 1: Estimated current yield together with the median and 95% confidence interval for three indicators of interest. As B/BMSY is below 1.0 (MSY reference point), the stock should be designated as overfished. Catches are currently likely to be below the replacement yield, so that the stock size should increase, albeit slowly. Reduction in catch should speed recovery and reduce the risk of further overfishing. Since the current catch is likely to be below MSY, once the stock starts to recover, it should rise above the MSY level.

Current Yield (t)		35	
	5%	**Median**	**95%**
B/BMSY	0.60	0.74	0.88
Replacement Yield (t)	34	45	54
MSY (t)	37	48	58

3.3 Management Advice

It is essential that measures are put in place to contain the level of effort to ensure the sustainability of the fishery. It is therefore recommended that the current catch remains at the same levels (35 tons per year) or lower. This is necessary to ensure rebuilding of the current stock. If no recovery is detected in future years, catches will need to be decreased. Management could:

- seek to control effort through a licensing system where only traditional conch fishers are allowed into that fishery, and/or
- introduce a closed season to limit effort. The Fisheries Regulations make provisions for a closed season but, to date, this management measure has not been implemented.
- fully enforce regulatory actions enacted in the law.

3.4 Statistics and Research Recommendations

3.4.1. Data Quality

The annual catches need to be re-estimated using the raising factors from the original data, and more catch and effort data might be available to extend the time series back to earlier years. In earlier years, it was thought that the shell weight was included in the reported catch weight of the trip, so an adjustment was made. This adjustment was later found to be incorrect. The adjustment was reversed both in the catches and CPUE data at this meeting. It was unclear whether this correction was necessary for all years in the catch time series. In particular, the 1996 catch appears too high.

With the exception of the problem noted above, the catch and effort data is believed to be very reliable. From 2000 to the present, all catch and effort data have been subjected to integrity checks both before and following data entry. Before data entry, data sheets are checked for errors and omissions with the data collectors, whilst subsequent to data entry into the Trip Interview Program (TIP) database, data are also validated and verified for errors and omissions.

3.4.2. Research

The following are suitable data for providing advice necessary for meeting management objectives:

- Catch and effort: The catch and effort data are monitored well, although past raising to total catch will need to be reassessed.
- Abundance survey: A survey has not been conducted but could be useful in helping to determine stock status.
- Habitat mapping: Area of conch habitat and fishing grounds would be useful in helping to identify realistic harvest from this species.
- Mapping of the fishing grounds and conch habitats should be carried out as soon as possible. This would make the stock assessment more reliable and would enable the management authority to manage the resource more effectively through for example zoning and declaring closed areas if necessary.
- An abundance survey would give an accurate estimate of the current biomass as well as identify juvenile and breeding areas. This would improve the accuracy of the assessment and give more options for appropriate management and control of this fishery.

3.5 Stock Assessment Summary

A stock assessment was carried out using the catch and effort data collected since 1993. The data were insufficient to estimate the stock size and production, therefore additional information on the biology of the stock was added from assessments in the Turks and Caicos Islands and Jamaica. Together with the catch and effort data from St. Lucia, this information was sufficient to determine the state of the stock and maximum sustainable yield for this fishery.

A simple biomass dynamics (Schaefer) model was fitted to a CPUE index (Figure A) using the catch estimates. The additional "prior" information on the population parameters (rate of increase and unexploited stock size) was included as mathematical probability functions based on assumptions and errors in the estimates from the Caicos Bank and Pedro Bank assessments. Including uncertainty is a marked improvement on previous assessments where fixed values had to be assumed, producing unreliable results. The model is fitted using a Bayesian fitting method that combines the information in the prior and the observations to produce a "posterior" probability for the state of the stock, MSY, replacement yield and other indicators of interest. The model fitted the data well (Figure B), but results depend upon the prior information being reasonable. The results were considered sufficiently reliable for adaptive management action.

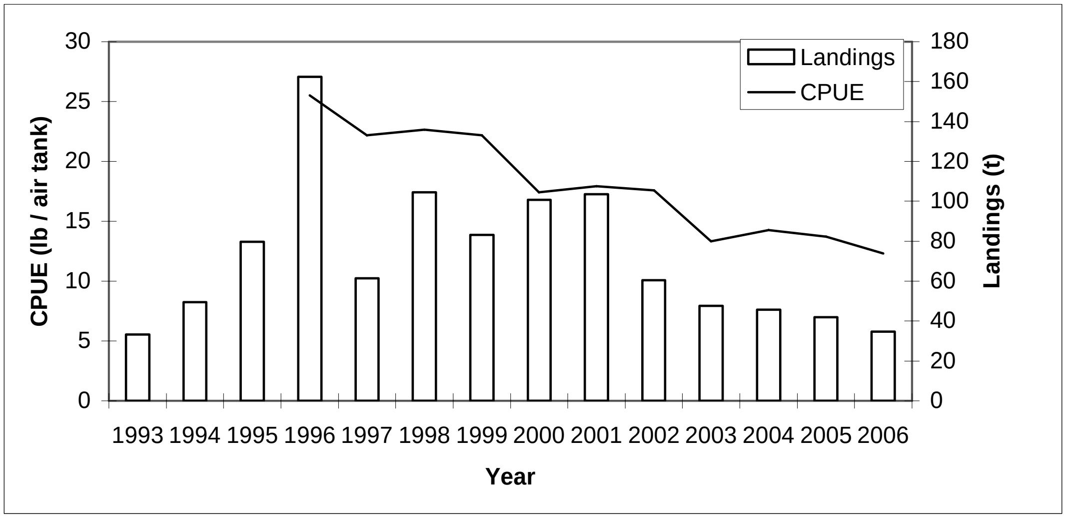


Figure A: The available total catch and CPUE data used for the stock assessment. The CPUE abundance index shows a continuous decline since 1996, suggesting that the stock has declined over this period. The catch time series 1993-2001 has some uncertainty as to the recorded data (see data quality).

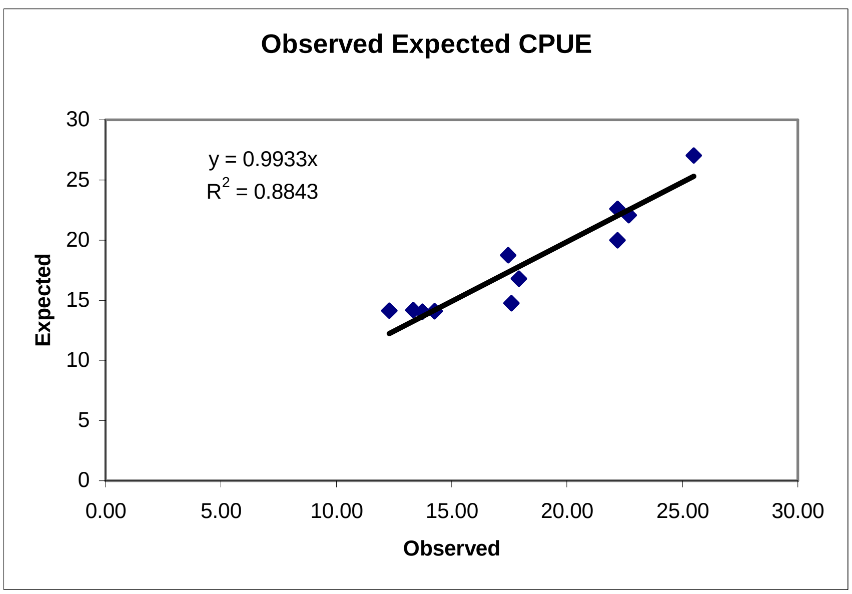


Figure B: The model explains the observations well, as indicated by the close fit between the observed and expected CPUE index. The R^2 statistic indicates that most variation in the CPUE index (i.e. the downward trend) can be explained by the model. However, wide ranges of parameter estimates explain the observations equally well unless additional information on the productivity of this species elsewhere is incorporated.

3.6 Special Comments

The priors for the unexploited stock size and rate of increase are probably both biased upwards. Both the Pedro Bank and Caicos Bank are likely to have more appropriate conch across the shelf than St. Lucia. St. Lucia is a volcanic island resulting in much of the shelf area being significantly deeper than 50m compared to these other banks, and probably makes the stock smaller (lower B_∞) and possibly less productive (lower r). Representing the prior information as probabilities has allowed the observed catch and CPUE series to correct this, since with higher population size and productivities the decline in CPUE would not have been observed. Nevertheless improved prior information based on actual conch habitat areas in St. Lucia would improve the accuracy of the assessment.

3.7 Policy Summary

- Maintain or restore populations of marine species at levels that can produce the optimal sustainable yield as qualified by relevant environmental and economic factors, taking into consideration relationships among various species.
- Preserve rare and fragile ecosystems, as well as habitats and other ecologically sensitive areas, especially coral reef ecosystems, estuaries, mangroves, seagrass beds, and other spawning and nursery areas.
- Protect and restore endangered marine and freshwater species.
- Prevent the use of destructive fishing gear and methods.
- Take into account traditional knowledge and interests of local communities, small-scale artisanal fisheries and indigenous people in development and management.
- Develop and increase the potential of living marine resources to meet human nutritional needs, as well as social, cultural, economic and development goals in a manner which would ensure sustainable use of the resources.
- Ensure effective monitoring and enforcement with respect to fishing and other aquatic resource uses.
- Promote relevant scientific research with respect to fisheries resources.
- Ensure that the fishing industry is integrated into the policy and decision-making process concerning fisheries and coastal zone management.
- Promote a collaborative approach to freshwater and marine management.
- Co-operate with other nations in the management of shared and highly migratory fish stocks.

3.8 Scientific Assessments

3.8.1 Background or Description of the Fishery

The Queen conch, *Strombus gigas* is one of the single species near shore fisheries of Saint Lucia. Presently, near shore stocks have been over exploited, thus most fishers harvest at deeper depths with SCUBA gear. Although this species is thought to be distributed around the island, only two significant populations have been identified, one to the north and the other to the south of the island. Information obtained from a recent survey of vessels targeting conch resources indicated that divers harvest conch regularly from various areas off Cas en Bas, Esperance, Grand Anse, Gros Islet, Mennard and Marisule in the north; Vieux Fort and Caille Bleu in the south; and Dennery on the east coast. Conch vessels target, on average, three areas on a rotational basis. At this point the northern population is thought to be more heavily exploited than the southern population.

Conch is exploited commercially all year by over 40 fishers in depths ranging from 11 m to 43 m. Fishers operate mainly out of fiberglass pirogues ranging in length from 7.02 – 8.45 m, powered by outboard engines of 115 – 250 hp. Whilst conch is targeted commercially by some fishers throughout the year, others fishers focus their efforts on this resource during the low period for "offshore" pelagic species, for, on average, five months. Fishers of this resource can be divided into part-time and full-time. Full-time fishers conduct dives on an average of four times each week alternating harvesting and rest days, whilst part-time fishers operate twice each week (DOF-Conch divers' survey, 1999). The majority of divers conduct greater than three dives per trip and approximately 100 – 500 individual conch are landed per trip. The quantity of conch landed is dependent on the number of divers and the number of dives conducted during the trip. Subsistence exploitation in shallower areas occurs but the extent is unknown.

Due to the nature of the fishery, the marketing system and an informal policy of the Department of Fisheries, the majority of conch harvested are landed whole (live) and then sold immediately or stored in wire-meshed cages in shallow areas close to shore until sale is obtained.

3.8.2 Overall Assessment Objectives

The main objective of this assessment was to determine the status of the stock and to derive a MSY based reference point for the St. Lucia conch stock.

3.8.3. Data Used

Name	Description
Catch and effort data	Observed conch landings using trip interviews (TIP)
Total conch landing	Annual landings from 1993 to 2006 raised from the CPUE and active vessels registered with the department of fisheries.

3.8.4. Assessment 1

3.8.4.1 Objective

The initial aim was to review CPUE as possible indices of abundance and consider standardisation to improve CPUE as an index of abundance.

3.8.4.2 Method/Models/Data

The data were reviewed and three options for a CPUE index were identified. There were no options for standardisation. Vessels do not vary much in size, and only the target species, conch, is caught on a trip. However, several options were available as a measure of effort. Vessels operate over one day, leaving in the morning and returning later that same day. The trip, hours fishing, man hours fishing, and number of air tanks used were all available as recorded information in the database. Any or all could provide a good measure of work done to catch conch.

There were two criteria considered in choosing an appropriate measure of effort. Firstly the degree to which the measure is correlated with the trip landings, and secondly, the linearity of this relationship.

The correlations between trip catch and effort was found to be correlated for all measures of effort to approximately the same degree (Table 1). All were significantly different from zero, so any of these measures were more desirable than using trips as the measure of effort. The highest correlation was found by multiplying the three available measures, suggesting that to some extent they were measuring slightly different activity within the trip, but this combined measure has no real meaning, therefore was not used.

Table 1: Correlation coefficients between the trip landings and various effort measures which could be used. On this basis, the hours at sea or crew*hours appear to perform a little better than the number of tanks, but there was some concern that the relationship was not strictly linear. The number of tanks was taken forward for the stock assessment.

Number of Tanks	Hours at Sea	Crew * Hours	Crew * Hours * Tanks
0.487	0.548	0.552	0.611

Of the three measures, the number of tanks seemed subjectively the most linear in its relationship with catch and consistent in the way it has been recorded over the years. Crew hours appeared non-linear, showing an asymptotic relationship, perhaps because the search area does not increase linearly with crew size (Figure 1).

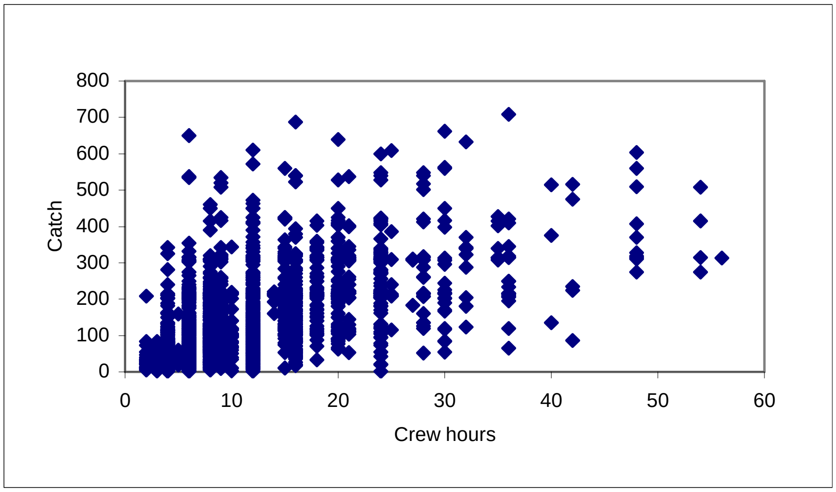


Figure 1: Results suggest that the catch may not increase linearly with crew hours at sea, with some evidence of diminishing returns to crew size.

<u>3.8.4.4 Discussion</u>

Number of tanks used was chosen on this occasion as the measure of effort, but the measure was not definitive and hours at sea could also be used. There was little expected difference for an assessment between the measures.

The number of tanks may not be recorded as the number of air tanks actually used on the trip. Fishers may carry additional tanks for storage and safety. This was considered weakness of this measure. In addition, if the average depth of fishing ground has changed over the period, the catch-per-tank may decrease because of decreased bottom time with depth. This would most likely lead to a decline in abundance that is not as steep as currently indicated, so the current assumption, that depth has not increased, is precautionary.

Future assessments should reconsider which effort measure to use, and conduct more formal analyses to test for linearity and possible transforms.

3.8.4. Assessment 2

<u>3.8.4.1 Objective</u>

Using the CPUE index developed in Assessment 1, conduct a full stock assessment.

<u>3.8.4.2 Method</u>

Overview

The available data suggests a biomass dynamics model is a suitable assessment method for these data. The Schaefer model is widely and successfully used for conch fisheries such as the Turks and Caicos Islands and Jamaica in setting TAC. The short pelagic larval stage (2-3 weeks), make it likely that in many cases conch forms independent populations which are predominantly self-recruiting. The model appears to have the ability to describe changes in CPUE and in the case of the Turks and Caicos Islands estimates a biomass close to the abundance survey. Therefore, without evidence to the contrary in a particular case, the logistic (Schaefer) model is appropriate.

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 proposed priors are based on a preliminary method, as no standard method exists. The method is important as it affects the final outcome. A standard approach ensuring results are precautionary would be valuable in using this method. The catchability parameter (q) prior is assumed uniform (uninformative) on a log scale.

The initial state of the stock at the start of the catch time series is stock specific and so information from other assessments cannot be used. The longer the catch time series, the less important this parameter is. Extending the catch time series is therefore an important recommendation and maybe possible if historical data can be recovered. The proposed initial stock state prior (Figure 2) was subjective and based on general observations in previous reports that exploitation had increased in recent time with markets opening up in neighbouring islands. Therefore the stock was assumed unexploited in 1993, but otherwise the state of the stock at this time was uncertain.

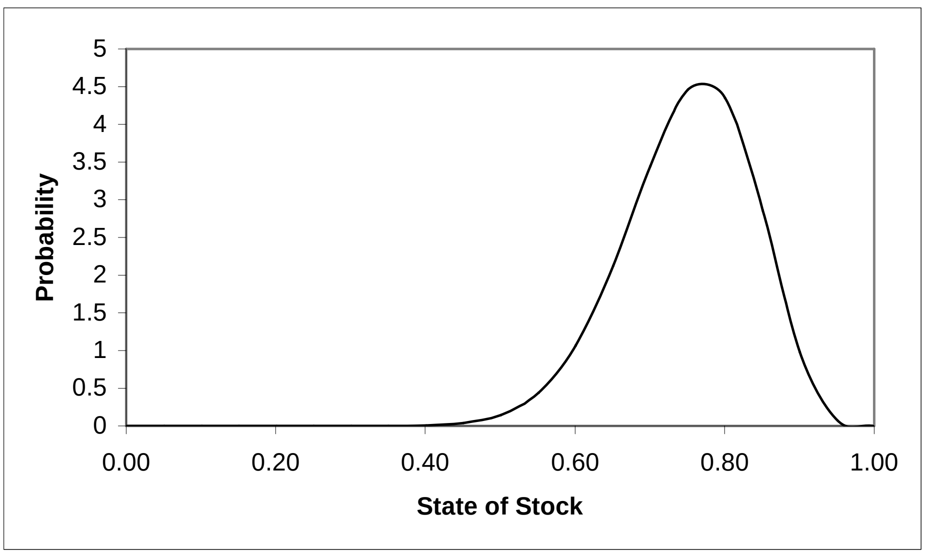


Figure 2: The beta distribution for the prior of the initial stock state (α=18, β=6, μ=0.75). The initial state probability was subjective, but based on the assumption that the stock was very unlikely over-exploited (below MSY) in 1993, but some exploitation was occurring, so that almost all the probability mass was between 0.5 and 1.0. The fishery expanded when markets opened up in neighbouring islands. This was assumed to be occurring 1993-1996 in the time series, but should be verified.

The rate of increase will be an attribute of the species and affected by the local habitat. A prior based on the species is the most appropriate. As data become available, this should be updated by local productivity information. The only estimates for rate of increase were for the Turks and Caicos 2003 assessment (cf TCI conch assessment this report). A beta distribution was fitted to the bootstrap estimates for the r parameter (Figure 3), and adjusted to increase the uncertainty (the β parameter was rounded down from 12.4 to 10, flattening the beta function). Increasing the uncertainty in the prior makes the prior less informative and lowers its influence of the results. Given that the location and therefore productivity may change, this is good practice, but there is no standard approach.

The unexploited abundance prior (Figure 4) was based on a log-normal with hyper-parameters estimated from reported abundance and unexploited biomass for the Pedro and Caicos banks (Table 3). While the various estimates for tons per hectare covered the likely range, the total habitat area for St. Lucia was unknown. An estimate based on the shelf area to the 200m contour was used, but was probably too high. A more consistent approach might be to use the fished area, which could be estimated for St. Lucia over the next year.

Table 3: Values obtained for Pedro and Caicos Banks to estimate the range for the St. Lucia prior for the unexploited biomass (B_∞). The tons per hectare were raised for the St. Lucia by multiplying by the presumed habitat area (45500 ha 85% of the shelf area to 200m depth contour). The highest and lowest biomass estimates were used to define the 80% interval for a log-normal, with resulting parameters μ= 6.75, σ=0.27.

Source	Basis	Area (ha)	Biomass	t / ha	St. Lucia (t)
Pedro Bank 2002 abundance survey	Current survey biomass estimate	571700	14556	0.0255	1177
Pedro Bank MSY	Confidence interval from reported MSY confidence interval, assuming *r*=0.5		10400 14400	0.0182 0.0252	841 1165
Turks and Caicos Islands	Estimated B_∞	650000	8636	0.0133	614

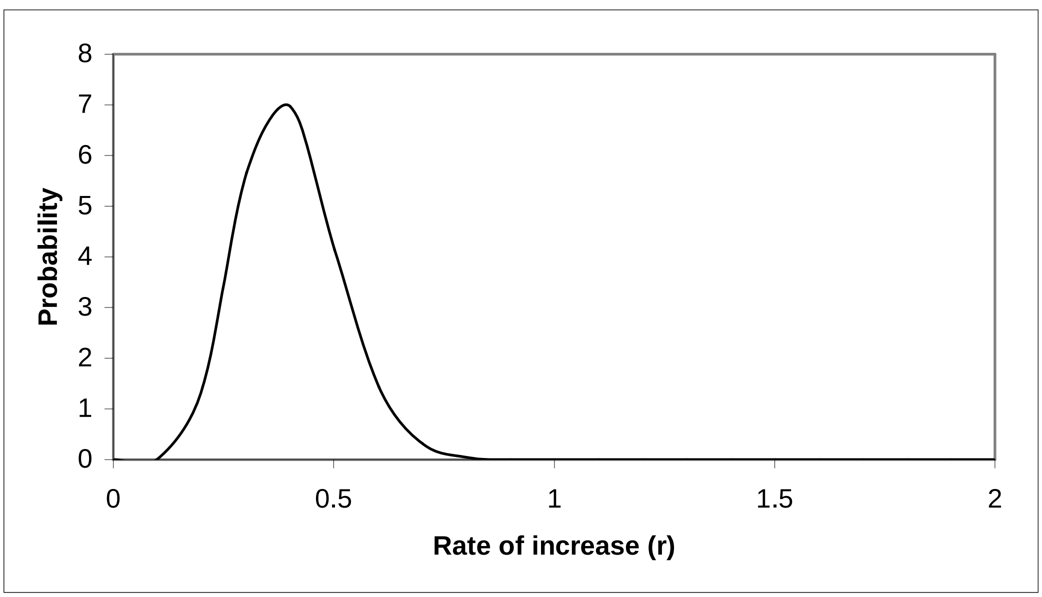


Figure 3: Beta distribution for the rate of increase (*r*) prior fitted to bootstrap estimate frequencies from the 2003 Turks and Caicos Islands (α=40, β=10, μ=0.2; x values are multiplied by 2.0 to get the *r* parameter). The value is limited to exist only between 0 and 2, outside this range the model becoming unstable and biologically unrealistic.

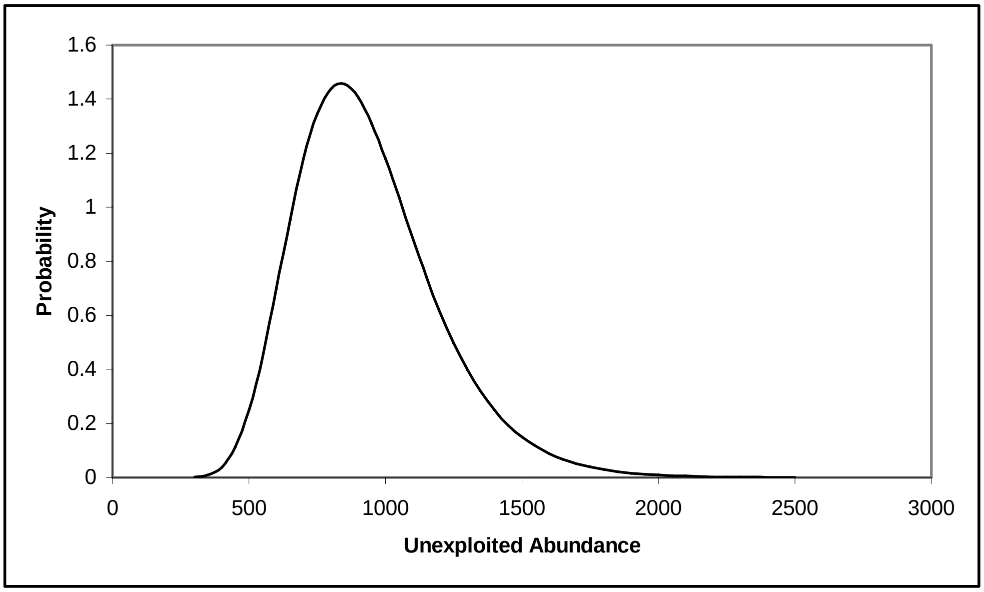


Figure 4: Log-normal probability density for the unexploited stock size. The prior was designed so that 80% of the probability mass was between the minimum and maximum values derived from the Turks and Caicos Islands and Jamaica assessments corrected for the smaller St. Lucia shelf area, and further subjective precautionary correction.

The priors are provided as independent parameters. In the case of Turks and Caicos for example, the r and B_∞ parameters are correlated and a prior based on this stock assessment, it could be argued, should reflect the correlation in the estimates. While this issue could form the basis for an exploratory analysis, it may be considered an over-interpretation of a prior as the posterior from this stock assessment. A prior should be general, and not too prescriptive as to obscure any information in the data specific to the fishery.

Likelihood

The likelihood for the observations was the normal (Gaussian) probability density function fitting between the observed and expected CPUE index. The expected CPUE index is calculated as the catchability parameter multiplied by the biomass abundance. The variance (σ) parameter was not fitted using Bayesian methods but fixed at an estimated value. The parameter was estimated from the squared residuals between the observations and a smoothed CPUE series (moving average).

The catches also were not fitted, although they could have been if the sampling error was to be included. This source of error was small, and least squares fitting suggested allowing for this sampling error would make little difference to the assessment.

Fitting Method

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 favoured choice is Monte Carlo Markov Chain methods (MCMC). This set of methods is flexible and generally works under most circumstances, but requires some skill to implement and does not necessarily work for "difficult" models. Detecting when the method produces poor results is not necessarily easy. The logistic model, behaves in a complex and difficult manner which belies the small number of parameters taken to fit it. Because of these and similar problems encountered when fitting this and the standard biomass dynamics model, an alternative approach was used which allows either rejection sampling or sample-importance-resample (see Gelman *et al*. 1995):

1. Rejection sampling takes random samples from the approximating distribution and rejects each sample with a probability based on the difference in height between the approximating and target function. The rejection step applies a correction which guarantees that the final set of accepted values will essentially be drawn at random from the underlying posterior if the approximating function covers the target function (i.e. The approximating function is greater than the target function across all parameter space). This is the preferred method as checking is straightforward and numerical fitting errors can be minimised.

2. Sampling importance takes random samples from the approximating pdf and calculates a weight based on the ratio between the approximating function value and the target function. These weights can be used to apply a correction to the integration, as well as form the basis of the resampling step of the SIR algorithm. The SIR algorithm attempts to generate a draw of parameter values from the target function with equal weight. The sampling importance has the advantage over the rejection algorithm in that the approximating function need not cover the target function, which is difficult to guarantee. The problem with the method is that the accuracy can be poor, as indicated by a wide range of weights, a problem which can only be addressed by an improved approximating function.

If a good approximating pdf can be obtained, both these methods work and can be verified by checking the ratio of the approximate to the target pdf and/or the rate of rejection.

The method used here builds an approximate pdf from repeated sampling from the target posterior function. An ideal approximating function should be proportional to the target pdf, and easy to draw random values. The method used here makes use of methods for representing normal mixture approximations to multimodal densities (Gelman *et al.* 1995) and fitting kernel smoothers to approximate densities when a random draw is available (Silverman, 1986).

The method is applied as follows:

1. Make a random draw of the variables from the current approximate density.
2. Calculate the approximate and target function values and the difference between the two.
3. IF the approximate function is greater than or equal to the target function, THEN accept the values with probability (Target F)/(Approximate F), otherwise reject them OR accept the importance sample recording the importance ratio if the importance ratio is not too high.
4. ELSE the approximate function is less than the target function OR the importance ratio is too high, so add another normal kernel to the approximate density:
    a) Find the mode of the difference function being the target minus the approximate function.
    b) Calculate the kernel weight as the ratio of the height of the kernel normal to the height of the difference function.
    c) At the mode, calculate the hessian matrix (partial differential matrix) and invert it. The inverted hessian matrix is covariance matrix for a multivariate normal

distribution. Adjust the estimated matrix to best fit the local difference function and ensure the matrix is a valid covariance matrix (positive definite).

d) Add a "kernel" multivariate normal to the approximating mixture pdf with mean equal to the mode and covariance matrix to the estimated matrix above.

e) Repeat actions a) and c) until the original point is covered (target F – approximate F < 0 OR importance ratio is acceptable)

f) Discard all the draws from the target function to restart.

5. Repeat actions 1 to 4 until the required number of draws have been made.

The method has several advantages and one important drawback. The main advantages are that the algorithm should cover even very complex target posterior pdfs (albeit this may require adding a relatively large number of normals) and the method is easier to improve and manipulate manually. As an example of the latter, if any uncovered volumes are suspected, they can be pointed out manually to the procedure, which can then fill out these volumes in the approximate pdf if necessary without affecting the approximate distribution at other points. Therefore, as it proceeds, the fit becomes more and more accurate, and at any time a volume of unexplained probability is found it can be added to the approximate pdf. Once a good approximate pdf is estimated, draws can be repeated very rapidly.

The only drawback is that very large numbers of kernel normals may be required depending on the shape of the underlying target function. If the shape is close to normal, only a few kernel normals will be required. For most real-world problems this is not the case, and for fitting the logistic population model, this can be almost guaranteed not to be the case. While with only a 1-3 parameters even complex shapes do not present too much of a problem for the technique, 4-6 parameters (i.e. dimensions) can become a problem, as the pdf shapes in the hyper-volume can become very complex indeed. Beyond 6 parameters, in its current form the method may require so many kernel normals to adequately describe the target pdf that it becomes impractical to use rejection sampling, but the SIR algorithm can still be used.

As in any of these Monte Carlo techniques, including MCMC, it cannot be guaranteed that all probability mass is covered, and therefore some inaccuracy may result. By judicious choice of initial values and systematic searching across the parameter ranges, significant problems can be avoided. These methods should cover all contiguous probability mass, the only problems arising through isolated modes. The longer the method above is applied (i.e. Draws are made), the more likely it is that such probability masses will be found and the approximate pdf adjusted accordingly.

The method has been implemented using Visual Basic in an MS Excel spreadsheet. 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 (paul.medley@virgin.net).

3.8.4.3 Results

The fitting method worked well, and the model was able to apply the rejection sampling method. The results are therefore 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.

These results suggest that it is likely that the stock is overfished (Figure 1), but that overfishing is no longer occurring (Figure 2). The MSY suggests the fishery will be small, but that catches could be allowed to increase once the stock has recovered.

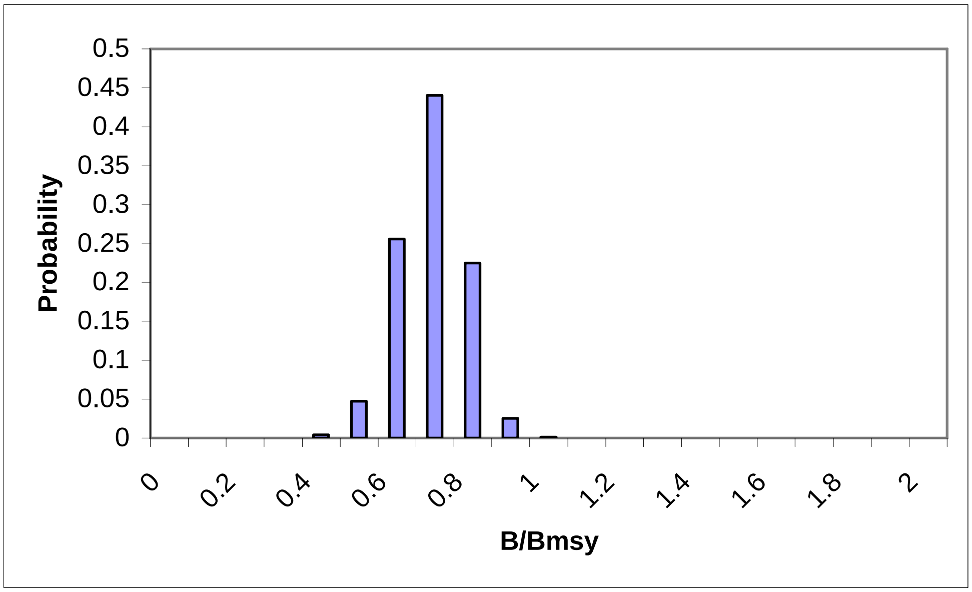


Figure 1: Stock status (Biomass / Biomass at MSY) for conch as a probability function based on the prior information on likely stock size and productive and the available catch-effort data. The results indicate that it is very likely that the current biomass is below the MSY reference point ($B/B_{MSY} < 1$).

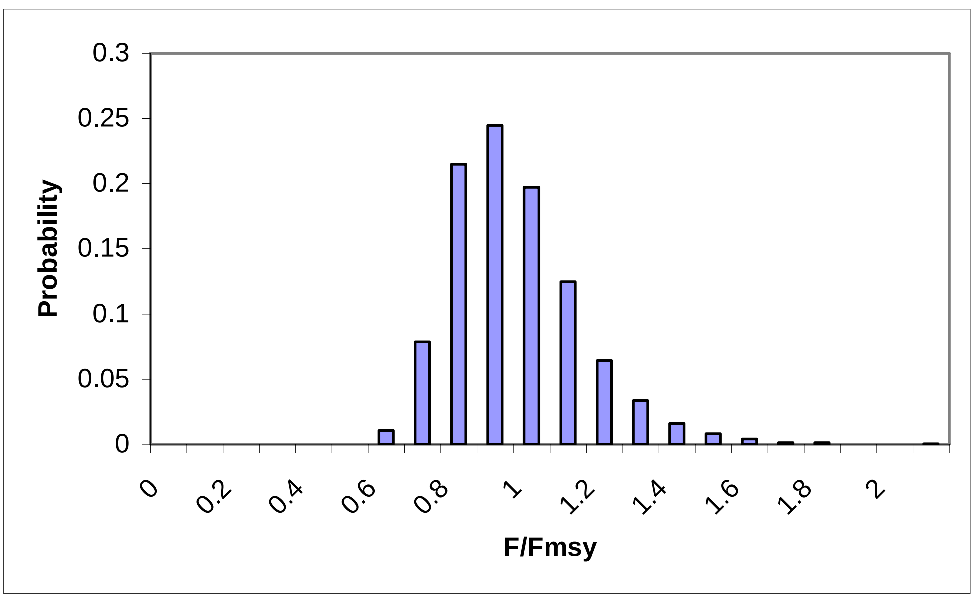


Figure 2: Overfishing status (fishing mortality / fishing mortality at MSY) for conch as a probability function based on the prior information and the available catch-effort data. The results indicate that overfishing ($F/F_{MSY} < 1$) based on a current catch of 34t, is not likely, but is quite possible.

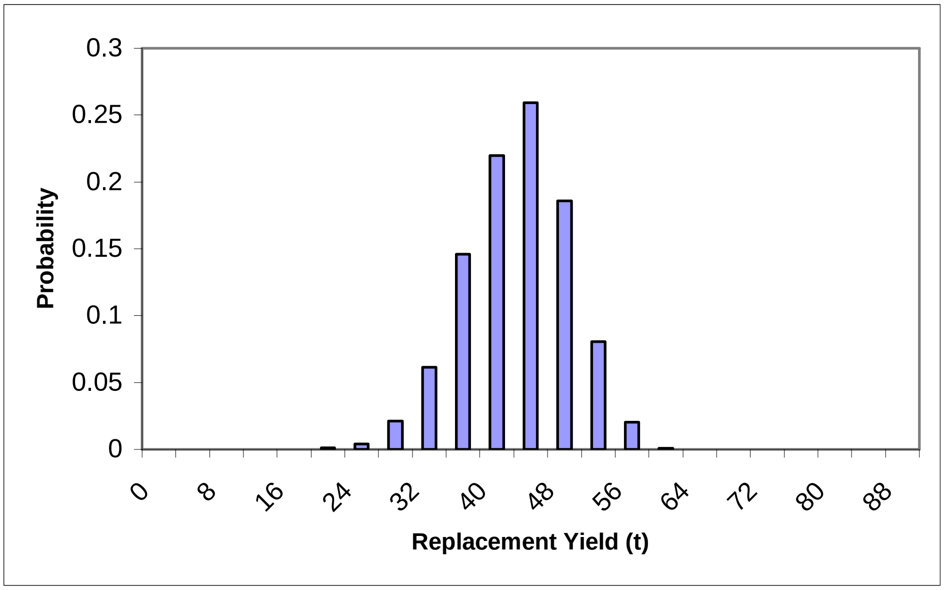


Figure 3: The replacement yield for conch as a probability function based on the prior information on likely stock size, productivity, and the available catch-effort data. The replacement yield is the current production from the stock, so that exceeding this yield will result in the stock biomass falling.

The results indicate that the current catch (34 t) is likely to be below the replacement yield so that the stock, and therefore CPUE, should increase. Overfishing may still be occurring however (Figure 2), and if it is, maintaining the current catch may not allow the stock to recover above MSY.

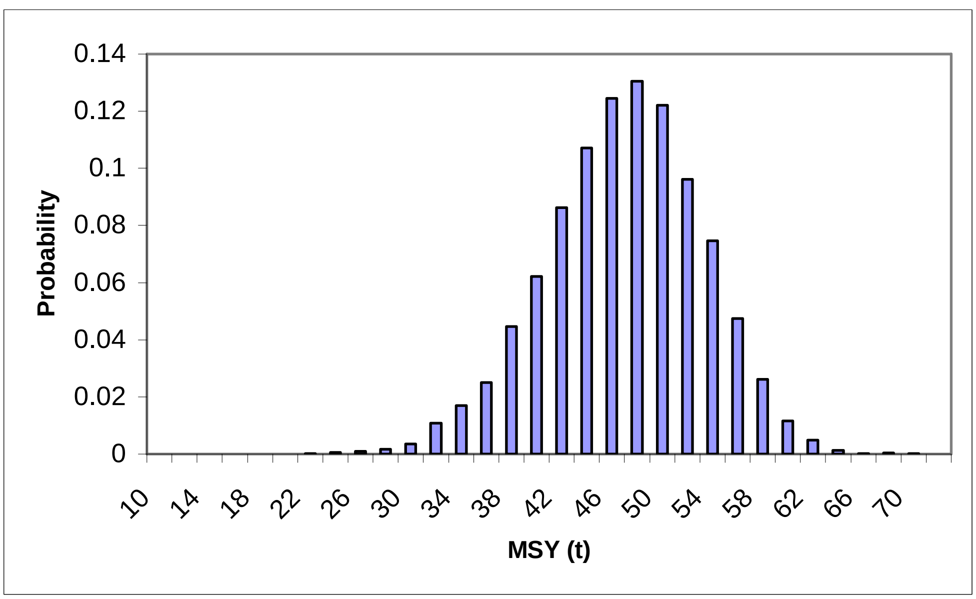


Figure 4: The estimated maximum sustainable yield suggest that yields above 50t are unlikely to be sustainable, and catches in general should be kept below this level. Lower catches would be more precautionary, and catches below 30t per year are unlikely to cause overfishing.

3.8.4.4 Discussion

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

- The CPUE index is proportional to abundance. Alternative CPUE indices should be developed and, if they are determined to be better than the current index, used in the assessment. In particular, the hours at sea should be checked and used as an effort measure.
- The biomass dynamics model is appropriate for describing the dynamics of the species. This assumption is difficult to test, but more information may become available as the time series is extended.
- Total catches are well estimated. The sampling error may underestimate the uncertainty as the raising factor is assumed to be known exactly.
- The information included in the priors is valid. Priors automatically become less important as the available data become more informative. However, with a monotonic decline in the CPUE indices, the priors are highly influential and therefore suspected bias in the priors may be present in the final results.
- The MSY based reference points are assumed to be an appropriate target reference point defining the lower bound before additional management action is taken. This is an interpretation of the stated policy.

The results indicate that the stock is overfished, but it is likely that the stock biomass should recover if catches remain constant. This is testable in the sense that the CPUE is forecast to increase in future even without management intervention as fishermen appear to have switched to alternative work, such as fishing other species. If CPUE can be increased over the next few years, the data will become much more informative on the rate of increase parameter.

For catches to remain constant, the fishing effort will need to be reduced over time. Management will therefore have to take action to keep the catch at the current level. If the CPUE continues to fall, more drastic action by management will be required. The main focus of management for this fishery should be to obtain a detectable increase in CPUE. A detectable increase in CPUE would:

- Demonstrate that management is able to control the state of the stock and of the fishery.
- Move the state of the stock to a target where it is not overfished (above the MSY level).
- Support the assumption that the CPUE index is adequate for monitoring biomass and performance of the fishery.
- Greatly improve the stock assessment estimates of MSY

The results depend upon the prior information introduced. There is no generally acceptable way to design informative priors. An array of alternatives were used here, but were not definitive. Other methods, such as polling experts or using models of the life history and the ecology of the species, would require inter-session work to obtain the data and conduct the analysis. Priors to represent likely values for the productivity which could be used in these sorts of models.

3.8.5 Recommendations

The next scientific workshop should develop and test this assessment to improve the management advice. The next assessment should include, but not be limited to:

Corrected, recalculated catches, with the estimated error, for the annual catches and the time series extended back as far back as possible.

Various sensitivity analyses including alternate CPUE indices, notably hours at sea which may be a better effort measure, and alternative forms of the biomass dynamics models.

The assessment can be used to estimate recovery times, test whether changes in CPUE will be detectable and indicate when recovery might be determined.

3.9 References

Gelman A., Carlin J.B., Stern, H.S., Rubin, D.B. (1995). Bayesian Data Analysis. Chapman and Hall, London.

Silverman, B.W. (1986). Density Estimation for Statistics and Data Analysis. Chapman and Hall / CRC, London.

4.0 The Spiny lobster (*Panulirus argus*) Fisheries of Jamaica

4.1 Management Objectives

The management objective for the spiny lobster fishery of the Government of Jamaica is "Biological sustainable use of the fishery resources in order to ensure present and future economic earnings from the fishery" (CFRAMP, 2000). There is no fishery management plan specific to lobster available to this meeting.

4.2 Status of Stock

During the present assessment of the spiny lobster the status of the stock could not be determined based on the available data at the Fisheries Division. The catch and effort data were too sparse across gears, months and fishing areas to allow any stock assessment. However, previous studies have been carried out by other researchers that indicate the possible status of the stock.

According to Munro, the lobster populations in Jamaica have changed considerably since 1983. Kelly (2003) noted that fishing effort had increased significantly in the preceding recent years and that the present level of fishing mortality appeared to be greater than the optimum recommended for the fishery in 2002. FAO (1993) indicated that from a biological perspective, fishing mortality should be reduced to minimize the risk of over-exploitation.

4.3 Management Advice

Although the state of the stock could not be determined from available data of the Fisheries Division, Jamaica has regulations which are not being enforced. Evidence from the catch and effort data collection programme indicates landings of lobster continue throughout the closed season. It is highly recommended that the Government of Jamaica pay special attention in ensuring that the current closed season is enforced. Possible considerations to enhance the effectiveness of the closed season are to prohibit the sale, processing and importation of lobster during this time. These measures would probably not only reduce the harvest of small lobsters, but increase the chance of detecting recruitment from the catch-effort data necessary for stock assessment.

It is also recommended that the Government of Jamaica pay more attention to this fishery and put in place the data collection activities that are required so that the current status of the stocks can be determined.

4.4 Statistics and Research Recommendations

4.4.1 Data Quality

Catch and effort data are gathered from various landing sites along mainland Jamaica (where lobsters are fished from northern and southern shelf, as well as fishing grounds in close proximity to the south island shelf) and the Pedro Bank for the period 1995 to 2007. Where they are collected, the data are reliable and accurate, but suffer from low sampling levels and gaps in the collection periods. Length frequency data were also available from various landing sites along the southern coast but few from the major fishing ground of Pedro Bank.

In an attempt to apply various assessments to the available data, significant gaps were identified. In some cases landings were reported with no effort. This could be as a result of data collectors omitting to ask that question or the providers of the data were reluctant. Consequently, some data from an already sparse data set had to be discarded. While the data are probably adequate for estimating statistics such as total catch, they are inadequate for determining catch rates by gear, month and location which are required for stock assessment.

4.4.2 Research

The sparse data collection resulting from the attempt to cover both the mainland and Pedro bank, suggests that more intense specific monitoring should be carried out on a single lobster fishery to determine the details necessary for a full assessment, as well as the seasonal patterns in landings, estimates of current fishing mortality and so on. The work could be conducted as a single one or two year project, although it would need to be conducted as a continuous activity during this period by dedicated staff to avoid any breaks in the time series.

The Fisheries Division has problems monitoring the wide range of fisheries undertaken in Jamaica. Any monitoring that can be undertaken by the fishing industry itself, notably the processing sector, would greatly enhance the ability to manage this fishery. One aim of such monitoring would be to establish a conversion factor from carapace length to tail length, so that a minimum tail length could be established which is consistent with the minimum carapace length.

The Fisheries Division is in the initial stage of carrying out a Lobster Casita Project which seeks to investigate a more efficient and sustainable system for the lobster fisheries. On a cautionary note, the Division should consider exerting its energy and resources into the enforcement of the regulations already in place for lobsters (especially minimum size and closed season) which will improve the status of the resources and also establish a more accurate recruitment index.

4.5 Stock Assessment Summary

No stock assessment was carried out as the available data were insufficient. However, exploratory data sought to identify any seasonal patterns in the CPUE indices as a preliminary to developing a recruitment index and monitoring trends in mean size. This assessment has resulted in the same results and conclusions of the work conducted at the WECAFC Spiny Lobster meeting in 2006 (FAO 2007), with additional corrections and verifications.

Recruitment Index

In an attempt to identify and establish a recruitment index, the available catch and effort data submitted for period 1995-2007 were examined. The total monthly CPUE was calculated by summing the catch and effort separately across the years and then dividing the summed catch by the summed effort. The mean CPUE by month (Figure 1) suggests that there may be a decline in catch rate from June to December. This may be the result of recruitment occurring during the closed season increasing the stock size at that time. However, the data are very noisy and sparse so any further attempt to separate out different effects was found to be impossible.

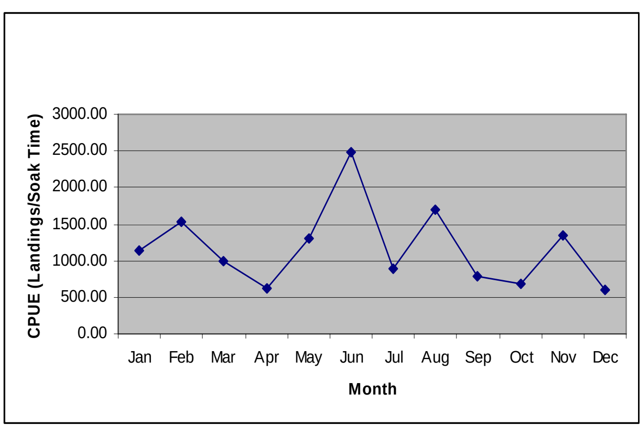


Figure 1: Monthly catch per unit effort (CPUE) for mainland Jamaica. The highest CPUE seems to occur in the middle of the year during and after the closed season.

Trends in mean Carapace Length (CL)

The length frequency data were used to examine changes in length and gear selectivity. The lowest mean carapace length was observed in August which lies at the margins of the present closed season (Figure 2). The results are consistent with, but cannot confirm, recruitment during the closed season. The sizes confounded with location and gear type. The hookah gear landed the largest lobsters while skin divers landed lobsters often below the minimum size (Figure 3). However, separation of the data simultaneously by gear and month or location significantly increased errors in the estimated means (Figure 4) or prevented estimation.

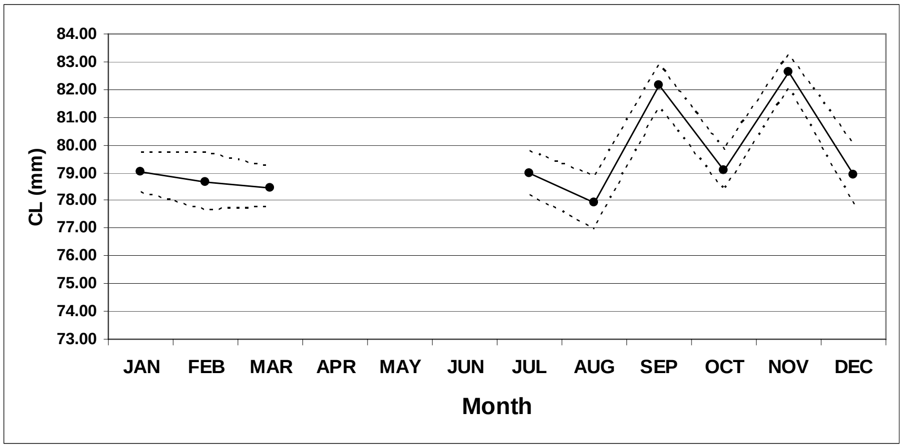


Figure 2: Seasonal differences in mean carapace length together with 95% confidence intervals for south Jamaica.

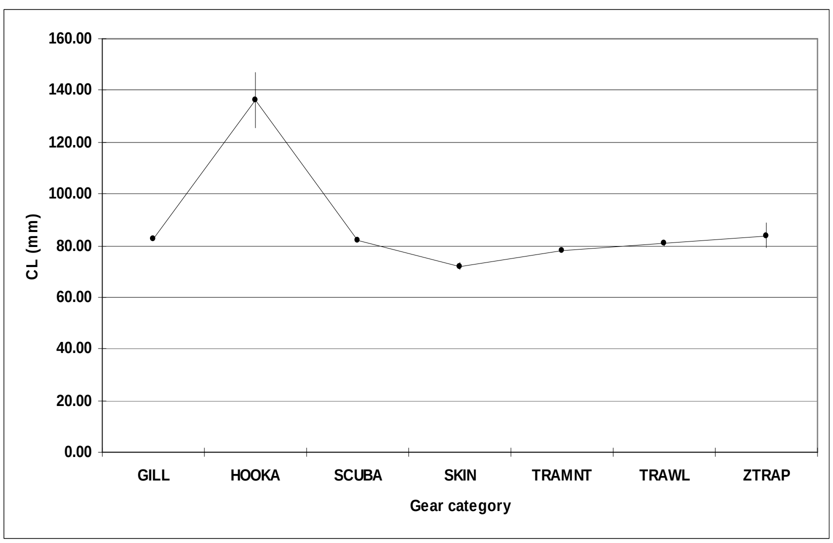


Figure 3: Mean carapace by gear for the Southern shelf and Pedro Bank combined, with 95% confidence intervals. Hookah, presumably operating in deeper water, landed the largest animals. Skin divers landed the smallest lobster, often below the minimum size (76mm CL).

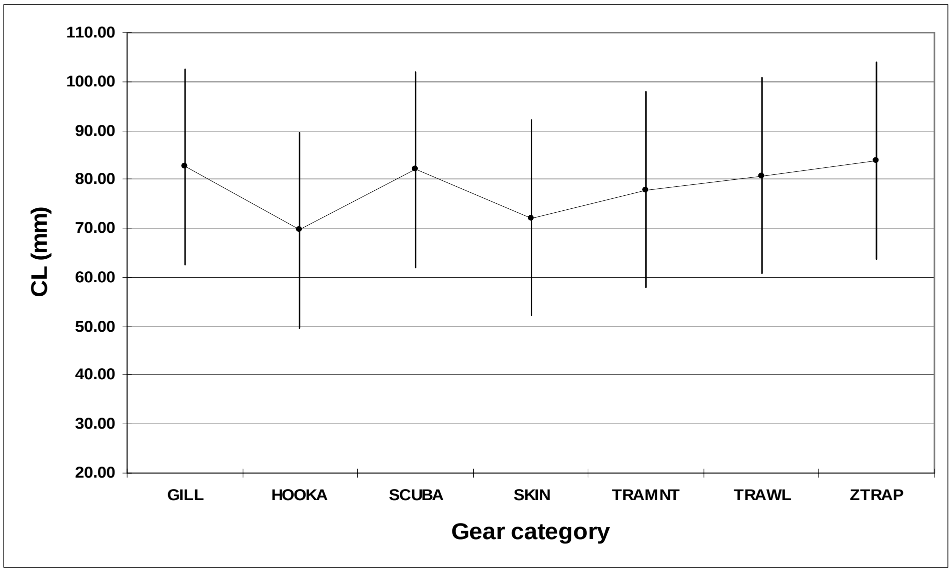


Figure 4: Mean carapace length by gear for the Southern shelf only, with 95% confidence intervals. The much smaller number of data makes it impossible to determine differences between gear types.

4.6 Special Comments

None.

4.7 Policy Summary

The goal to be achieved from proper management of the marine fisheries of Jamaica is the sustainable use of fisheries resources for the maximum benefit of the people of Jamaica. The objective for lobster is to restore/rehabilitate the fishery through protection of lobsters and protection and enhancement of their habitat.

There is need for gear restrictions, effort reduction, and enforced closed season and co-management arrangements. There is already legislation in place to prevent the taking of berried lobsters, and which prohibits the landing of lobsters during the close season. However, monitoring data suggest that these regulations are not enforced.

4.8 Scientific Assessments

4.8.1 Background or Description of Fishery

<u>4.8.1.1 Introduction</u>

Jamaica is located about 145 km south of Cuba and 161 km west of Haiti. The island is 236 km long, between 35 and 82 km wide, with a total area of 10, 940 sq. km and a coastline of approximately 885 km. The irregular coastline is punctuated by numerous coastal features such as harbours, bays, beaches, estuaries, mangrove, swamps, rocky shores, cays, coral reefs, and lagoons. Jamaica has a tropical maritime climate which is influenced by north east trade winds and land sea breezes. Average temperature is 27 degrees Celsius, ranging from 23 degrees C in winter to 28 degrees C in summer.

The fishing sector in 2005 contributed 0.31% to the Real Gross Domestic Product (GDP) for Jamaica, a 25% decline from the previous year.

The fisheries of Jamaica have over 20,000 fishers (16,840 registered fishers in May 2007); most of these are artisanal fishers operating from open canoes or reinforced fiberglass-type boats powered by either outboard motors or oars. There are approximately 9,000 boats (4,640 registered boats in May 2007), ranging from 4 to 9 metres, operating from 187 fishing beaches distributed around the Jamaican territorial waters. Vessels 12m and above, powered by inboard engines are considered industrial vessels.

According to Munro, the lobster populations in Jamaica have changed considerably since 1983. Kelly (2002) noted that fishing effort had increased significantly in the preceding recent years and that the present level of fishing mortality appeared to be greater than the optimum recommended for the fishery in 2002. FAO (1993) declared that from a biological perspective, fishing mortality should be reduced to minimize the risk of over-exploitation.

During the assessment of the spiny lobster fishery of Jamaica for the period of 1995 to 2007 the data available for analyses were 1) catch and effort data for various landing sites along Mainland Jamaica (which includes northern and southern shelf, as well as fishing grounds in close proximity to the south island shelf) and the Pedro Bank; 2) Length frequency data from various landing sites along the southern coast but a few from the major fishing ground Pedro Bank. These were then used to determine the recruitment index and trends in the mean carapace length as discussed below.

4.8.1.2 Description of the fishery

The spiny lobster, *Panulirus argus*, is widely distributed in the coastal waters and on the offshore banks around Jamaica. This resource is a delicacy and therefore highly priced and lobsters represent an important component of the total landings of the Jamaican commercial fishery. There are six types of lobsters that are found in Jamaican waters viz., *Panulirus argus, Panulirus guttatus, Justitia longimanus, Palinurellus gundlachi, Scyllarides aequinoctialis and Parribacus antarcticus*. *Panulirus guttatus and Panulirus argus* are the only two species that are commercially valuable (Aiken, 1984). A large concentration of lobsters is found on the Pedro Banks (Figure 1) which accounts for about 60 percent of the total landings in the industrial fishery. During the 1980s about 60 percent of total lobster landings came from the Pedro Bank but declined to 20 percent in 1996-1997. The contribution of lobsters landed in Jamaica that comes from the island shelf and the banks have not been recently quantified. Figure 2 shows the total production for the past nine years.

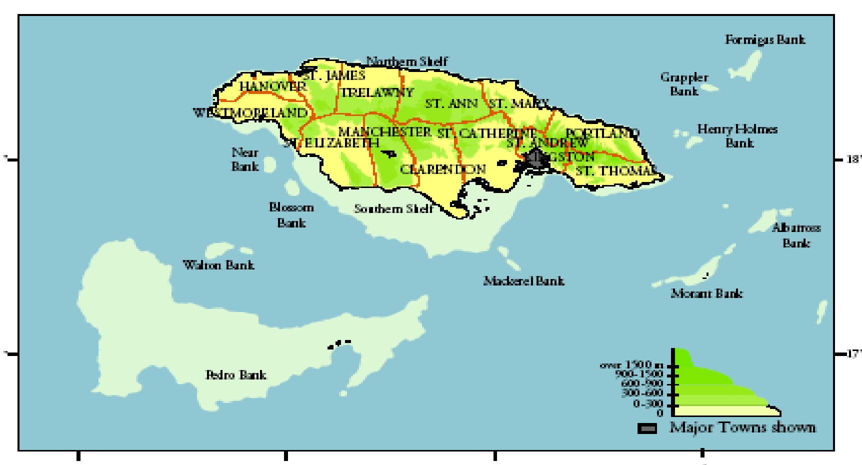
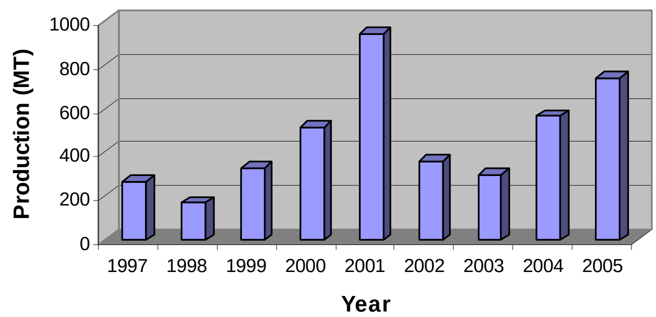


Figure 1: Jamaica's Fishing Grounds (Offshore and Inshore Banks)

Figure 2 Jamaica Spiny Lobster Production (MT) for the past nine years



Fishing for lobster is done mainly on the island shelf and the banks (Pedro Bank, Morant Bank and Formigas Bank). The fishery has two components, artisanal and industrial.

4.8.1.3 The artisanal fishery

This fishery is targeted by two categories of fishers:

a) Mainland artisanal fishers using Antillean Z-traps, diving (free lung, SCUBA and Hookah) and gill nets. The lobster is sold to the catering and tourist industry and households as well as to the processing plants.
b) Offshore artisanal fishers based mainly on Pedro and Morant Banks. Fishers in this category are mainly divers. The lobster is marketed to 'packer boats' who subsequently distribute to the same markets as the mainland artisanal fishers.

The crew size for the artisanal fishery is mainly three. The fish pot or trap is considered to be the primary gear; however, lobsters are usually by-catch in the trap fishery. A maximum of ten divers may travel in one vessel to the respective fishing grounds and the captain will keep watch while the divers harvest lobsters. Trammel net is also commonly used to capture lobsters. Lobster is sold locally to the public either at the boat side or via vendors. Vendors then distribute the lobster to the catering industry. Sometimes the catch is sold to respective fish processors. Figure 3 shows the weight of spiny lobsters caught by artisanal fishers using various gear types for 2005.

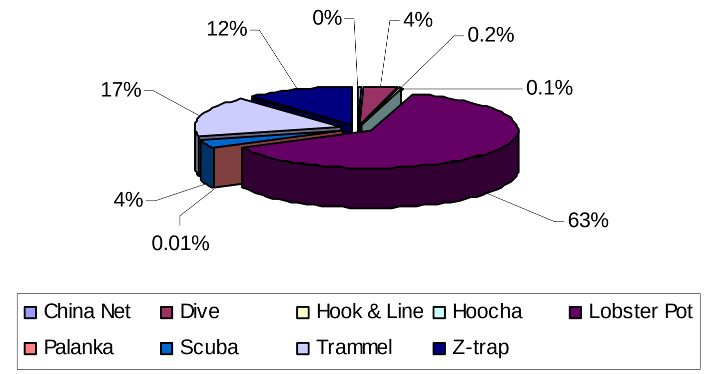


Figure 3. Percent Distribution of weight of Spiny Lobster landed by Artisanal Fishers using various Gears on the South Shelf of Jamaica in 2005

4.8.1.4 The industrial fishery

Fishers within this fishery are based on the mainland but operate mainly on the Pedro and Morant Banks from 20-35 m length vessels. These fishers are licensed to use Florida traps only. Most times they are contracted by the processors to whom they solely sell their catch. Fish processors cater primarily for the export market.

About ten industrial licences were issued to fish lobsters on the Pedro Bank using Florida traps in 2006. These vessels are operated by 4 companies. The vessels are steel hulled, 20 m x 5.7 m x 3 m and have inboard engines up to 500 hp. Crew size on these vessels ranges from 8 – 12. Vessels transport about 1000 traps and about 500 traps are deployed in the water at any one time. The average immersion time is about three days. Fishers spend up to three months at sea before returning to the mainland. Smaller quantities of lobsters may be transported back to the mainland by other vessel en route to the mainland. Lobsters are mainly exported to the United States, Canada, Panama, Netherlands Antilles, Cayman Islands and Martinique. The spiny lobster fishery is the second most lucrative export fishery. In 2001, the total production of lobster was estimated to be 308.92 MT valuing US $2,084,818.05. Landings for lobsters usually peak in March and late September.

4.8.1.5 Biology/Research

Several studies on lobsters have been conducted over the years a few of which are mentioned here. Studies conducted by Aiken (1977, 1983), Munro (1983) and Haughton (1988) confirmed a significant reduction in the mean and modal size of the lobster population in Jamaica. Haughton and King (1990) reported that the fishing effort has increased significantly and the present level of fishing mortality appears to be greater than the optimum required for the fishery. In 1991, a tagging study was conducted, but recovery was too small for any significant quantitative analysis. Young (1992) did a study on puerulus settlement rates on the south coast of Jamaica and found that settlement was continuous throughout the year.

In 1975, Fisheries Division records indicated that 76 percent of the commercial lobster comprised immature females (by comparison, Florida showed 17-21 percent immature females harvested), suggesting that there was an urgent need for strict management and protection. For 2005, 30 percent of the total lobster sampled was under the minimum size as described in the Fishing Industry Act of 1975.

The Fisheries Division is embarking on a new project called The Lobster Casita Project which seeks to investigate a more efficient and sustainable system for the lobster fisheries. This will be achieved through:

- Investigating the use of casitas in major fishery areas.
- Establishing juvenile enhancement systems
- Establishing pueruli (lobster larvae) monitoring programmes, which is useful for forecasting lobster catches.

The pilot project is being conducted in Bowden Bay, St. Thomas.

4.8.1.6 Management Regulations

The Fishing Industry Act of 1975 recommended a minimum size for spiny lobsters (*Panulirus argus*) of 7.62 cm (3 ins). Aiken (1977) recommended a gradual increase to 85 mm CL and Haughton et al (1986) also called for an increase in the minimum size limit to 89 mm CL as they found that about 55 percent of the females were mature at this length. It is illegal to land lobsters below this minimum size or offer such lobsters for sale. Female lobsters with eggs are also protected by the Act. Both provisions carry a maximum penalty of J$500 or six months in jail. This penalty is inadequate and certainly does not serve as deterrent to offenders. However, the Act is being revised to implement fines of greater magnitude.

In order to combat the decline of lobsters, further management measures were implemented such as a close season which runs from April 1 to June 30 annually. Further restrictions were placed on the industrial vessels, limited entry and gear restriction (Florida traps only).
Licences for the industrial lobster fishery are granted with the conditions such as:

a) All licensed lobster fishing vessels shall fish only in the areas specified by the licence
b) No fishing shall take place on the island shelf of Jamaica or on any proximal bank
c) All licensed lobster motor fishing vessels shall only fish, catch or land spiny lobster and no other species.
d) All lobsters caught, except undersized and/or berried which should be returned to the sea, shall be landed on mainland Jamaica no later than eight weeks after the commencement of each fishing trip.

Lack of adequate resources continue to incapacitate the effective enforcement of management regulations.

4.8.1.7 Monitoring, Control and Surveillance

Lobster closed season runs from April 1 to June 30, annually. Joint patrols are done with Police, Game Wardens and Fishery Inspectors both at sea and in food establishments and fishing beaches. Persons who intend to store lobsters during this period are asked to voluntarily declare the amounts to the Director of Fisheries prior to the commencement of the close season. Inspection teams then verify these amounts at these locations and issue a declaration certificate and inspection receipt.

The remaining three quarters of the year are used to undertake enforcement through the deployment of teams from the various supporting entities along with the Fisheries Division.

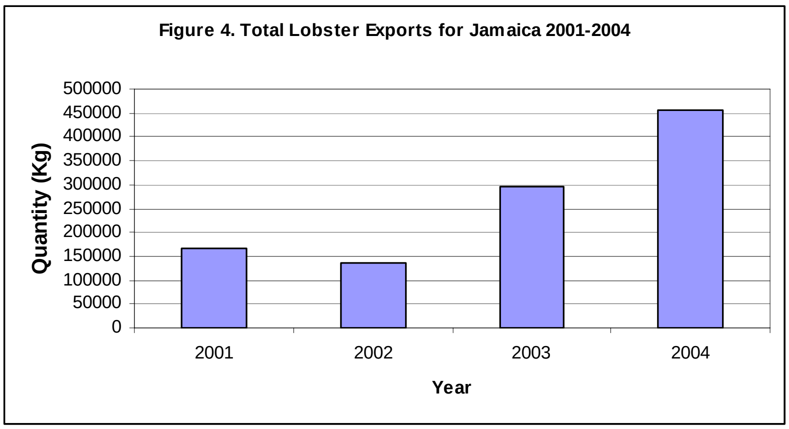
4.8.1.8 Available data

a) Fishery-dependent

The Data Collection Programme of the Fisheries Division was initiated in September, 1996 with assistance from the CARICOM Fisheries Resource Management Programme (CFRAMP). Catch and effort data are collected by gear from artisanal fishers through random stratified sampling. Data from the industrial fishers are collected by census. Biological data are collected where possible, usually on three gear types (SCUBA, free lung and gill net) and at two major landing sites – Hellshire and Bull Bay.

At the processing plants lobsters are landed tailed. The data collectors, therefore, measure tail length which then needs to be converted to whole weight and carapace length. Morphometric studies (carapace length, tail length, weight, telson length and carapace depth) were done on the Pedro Bank in an effort to easily convert from one measurement to another, while considering scientifically-based anomalies through these conversions.

b) Socio-economic
Since 1962 the exports of lobsters have increased significantly, from 0.68 percent in 1962 to 69 percent in 1995. Presently lobster is exported frozen, live, fresh, dried salted or in brine. In 2004 the country exported 457,068 kg of lobsters valued at US$4,130,567.74. Figure 4 shows lobster exports from 2001 to 2004.



Lobster is an important and sought after delicacy in the Jamaican tourist industry, luring visitors to savour the mouth-watering taste. A major portion of the lobsters landed in western Jamaica goes to the tourist industry. This portion has not yet been quantified. The peak demand for lobsters within the export and tourist industries is just before the start of the three-month Close Season. This demand coincides with increased fishing effort as consumers try to stock up on lobster. This clearly has management implications and in the new Fisheries Act, recommendations will be made to implement a total ban on the possession of lobsters during the Close Season. Table 1 shows a comparison of landings of lobster and other species groups in 2003.

Table 1: Quantity of fish type landed (2003) and the value.

Fish type	Quantity (MT)	Value (JA$)
Finfish	5172.54	1,026,304,351
Conch	546	216,668,088
Shrimp	-	-
Lobster	300	92,593,200

4.8.2 Overall Assessment Objectives
The overall objectives were to establish a recruitment index and examine trends in the mean carapace length.

4.8.3 Data Used

Name	Description
Catch and effort data	The catch and effort system target catch by gear types, since catch rates and effort differs by gear type. Lobster is caught using many different gear types; Antillean Z-traps, SCUBA, Free dive, Hookah and nets. The catch landed by each boat is recorded on a standard form and is submitted to the Data Unit.
Biological data	Samples are taken from landed catches where sex, maturity stage and carapace length are noted. The total weight of catch and sample of the catch is also noted. All biological data are linked to the boat in which sample is taken from.

4.8.4 Recruitment Index

4.8.4.1 Objective

The objective was to identify and establish a recruitment index from the available data.

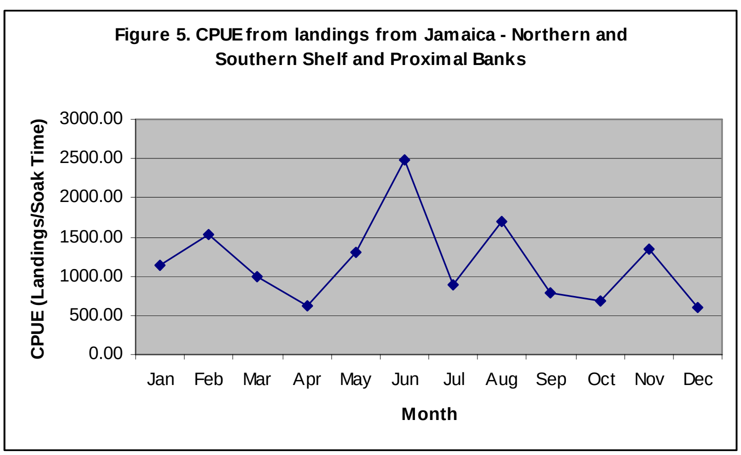
4.8.4.2 Method/Models/Data

In an attempt to establish a recruitment index the available catch and effort data submitted for period 1995-2007 were examined. The data were divided into two categories according to fishing grounds – Pedro Bank and Mainland Jamaica (which includes northern and southern shelf, as well as fishing grounds in close proximity to the south island shelf).

The total monthly CPUE was calculated by summing the catch and effort separately across the years and then dividing the summed catch by the summed effort.

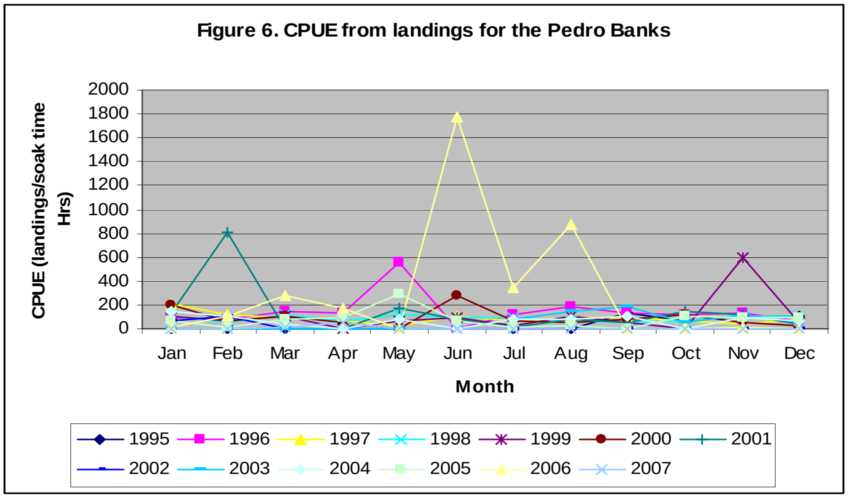
4.8.4.3 Results/Discussion

Figure 5 shows the total monthly CPUE from the landings of mainland Jamaica for the all years.

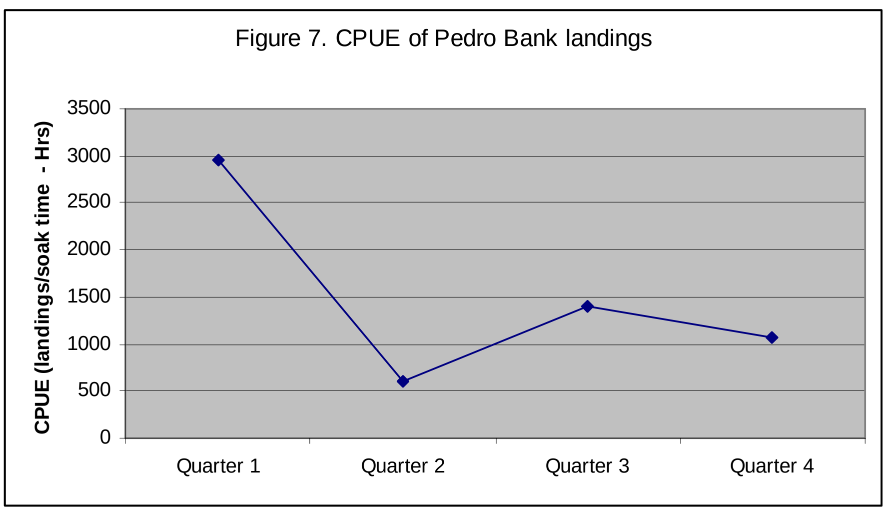


Since Jamaica has a closed season from April 1 to June 30, it was expected that the highest CPUE would have been attained in July. From the above figure it is quite clear that the expected pulse occurred in August, one month after the opening of the closed season. This suggests the possibility that recruitment may be occurring in August. However, it should also be noted that the highest peak was attained during the final month of the closed season. This has several implications one of which is that the closed season is not being adhered to as well as the greatest level of recruitment may actually be occurring during this time.

Figure 6 shows the monthly CPUE for each of the available years of the mainland landings and an observable similar trend is seen throughout most of the years, particularly the more recent years.



It should be noted that the present sampling plan only allows for sampling once per quarter on the Pedro Bank. Sampling period usually lasts for 6 to 7 days. Based on the data provided for Pedro Bank, sampling was not carried out in the same month of each year, and this makes it difficult to discern seasonal trends. Nonetheless, these data were plotted. Figure 7 shows the CPUE of Pedro Bank landings. The figure does show the highest CPUE occurring in the first quarter. This could imply that the fishers are increasing effort to stock up for the closed season.



<u>4.8.5 Trends in mean Carapace Length (CL)</u>

<u>4.8.5.1 Objective</u>

The objective was to examine trends in the mean carapace length from the available data.

4.8.5.2 Method/Models/Data

The majority of the biological data available were collected from fishers operating on the south coast of Jamaica. The mean carapace lengths for each month along with the 95% confidence intervals were taken and graphs plotted to examine seasonal patterns as well as yearly trends.

A) Seasonal Patterns

An observed marked decline in the mean length (in this case carapace length) was observed in the monthly landings. This can be used as an indication that recruitment is taking place on a notable scale. Figure 8 shows the mean carapace length for lobsters taken by the artisanal fishers along the south coast of Jamaica. Between January and March there is a decline in the mean CL. The lowest mean CL values were observed in March and August which lie at the margins of the present closed fishing season. It is possible therefore, that recruitment is occurring from the beginning of the year to as far as two months beyond the present closed season, with the strongest period being in the first quarter. It is unfortunate in this case that no data are available for the closed season which would have helped to give a better picture of what is happening.

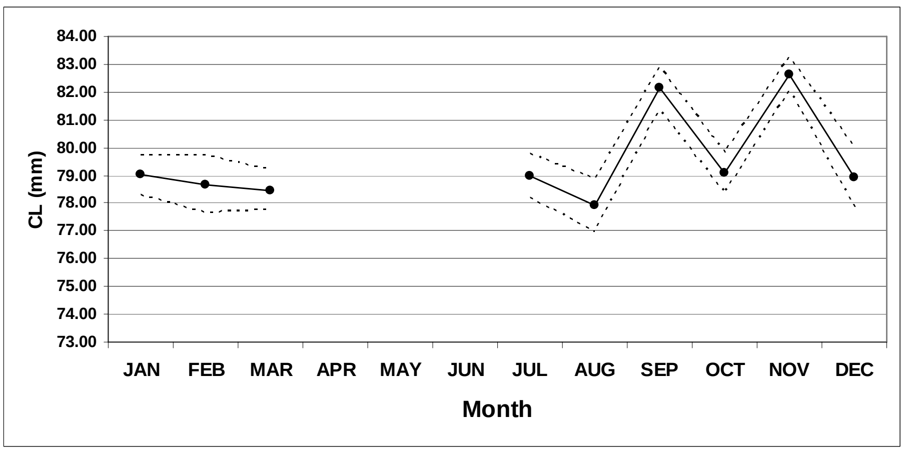


Figure 8: Seasonal trends in mean CL showing 95% CI´s – South Jamaica

The trend that occurs here is quite similar to that of Cuba's. Cuba has over 40 years of data for the entire island. They have found that to the east of the island recruitment takes place between February and June each year and to a lesser extent August to September (de Leon M.E., 2006, pers. comm.). This location is quite close to Jamaica and it is believed that a similar situation may also occur. This is quite important for the decision makers to either 1) increase the lobster close season to commence in March at the first instance and then to February; or 2) keep the present close season as is but designate certain areas as being closed to fishing during the recruitment period to protect the juveniles. In order for the second option to be implemented it would mean that further studies would need to be conducted to identify these areas of interest.

Benefits associated with increasing the lobster closed season are 1) protection of stock that is being recruited to the fishery and 2) protection of females with matured ovaries.

B) Yearly trends of mean CL

The mean CL for a ten year period is shown in Figure 9 below. It should be noted that years 1996 and 2006 represent an incomplete data set. It is unclear why there was an observable decline in 2005 but it might be related to the adverse weather conditions experienced in the previous year causing the relocation of larger lobsters to deeper waters.

The overall fall in size between 2002 and 2005 implies either fishing mortality has increased or there is increasing infringement of the minimum size, or both. It is noticeable that there was an overall increase in mean CL from 1997-2002. The sharp decline following an absence of data collection is surprising and will need to be verified by further year's data collection.

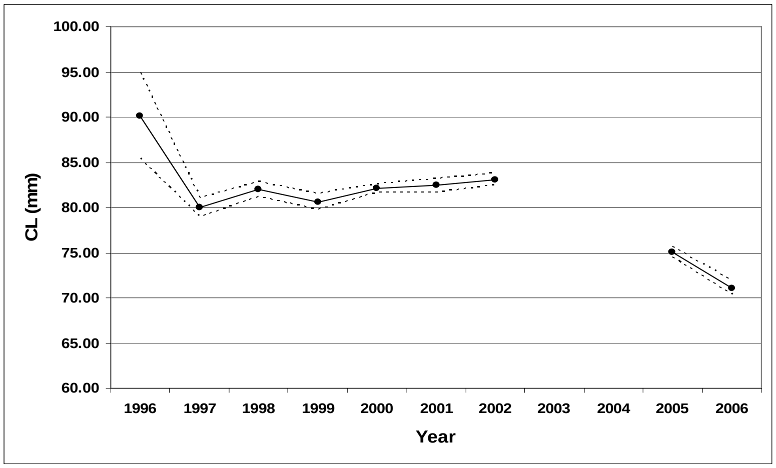


Figure 9: Change in mean CL during 1996-2006, showing 95% CIs - South Jamaica

C) Gear Analysis

Figure 10a illustrates the mean CL across the various gears used by artisanal fishers on both the Pedro Bank and southern shelf combined. This graph indicates that Hookah lands the largest sized lobster of all gears. What was not reported however, in this case were both the landing site and fishing ground exploited by these fishers. This is cause for concern as it uncertain whether lobsters were actually taken from the island's shelf or Pedro Bank. Another area of concern is the pros and cons of use of this gear. Admittedly, Hookah allows divers to remain under water for longer periods of time thereby increasing the fishing effort as well as access to greater depths where larger lobsters are found. However, the consequence is that the target now becomes the spawning stock. Larger/older lobsters tend to reproduce/spawn more frequently than younger matured ones. Hence, excessive removal of this stock leads to a reduction in recruitment.

The change in mean CL in the annual time series cannot be explained by changes in gears as all fishing gears show very similar selectivity, with the exception of hookah which lands the largest lobster, see also Figure 10b.

Figure 10a Change in mean CL with gear on Southern shelf and Pedro Bank, showing 95% CIs

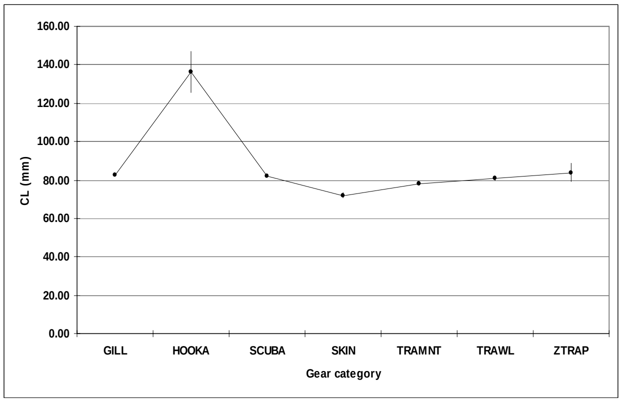


Figure 10b Change in mean CL with gear on Southern shelf, showing 95% CIs

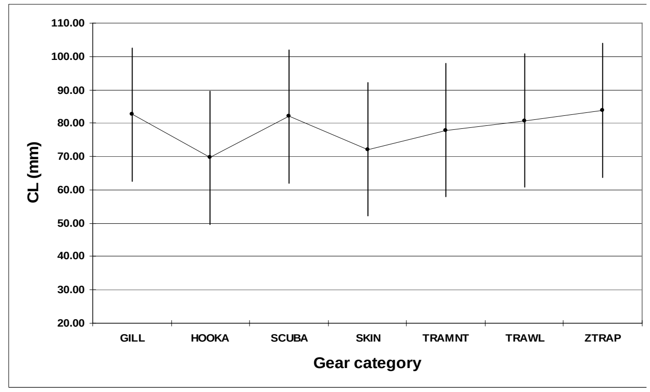


Figure 10b, which eliminated the Pedro Bank data, shows that scuba divers landed lobsters below the legal size. In most cases the fishing ground was not indicated but it is possible that these fishers are targeting the grounds of recruitment as in the case of skin divers (see below).

Gill nets and Z-traps are the gears that yield the second highest mean CL followed by Scuba, Trawl and Trammel net in both figures.

Considerations need to be given to the area of skin diving as this form of fishing practice lands lobsters well below the legal size. It implies that divers are restricted to shallow water depths where it is possible that the fishing area may be grounds of recruitment. Since this is not a major gear/fishing method since 2002 (Figure 10) it is recommended that considerations be made on how to manage these fishers as they may just be a few subsistence fishers.

Figure 11 shows the frequency distribution of the total number of lobsters landed by gear used during the period 1996-2006. During the period of 1996-2001 skin divers were quite predominant. The figure also shows what appears to be a shift in the use of the principal gear of scuba diving in the late 1990´s to trammel nets. These are not conclusive statements as the sample size varied over time and the fishing grounds also changed. Hence different sampling/landings sites contributed the different gears represented. Consequently, it is not clear as to whether the observed decrease in mean CL in 2005-2006 is a real decrease rather than a simple reflection in the distribution of sampling.

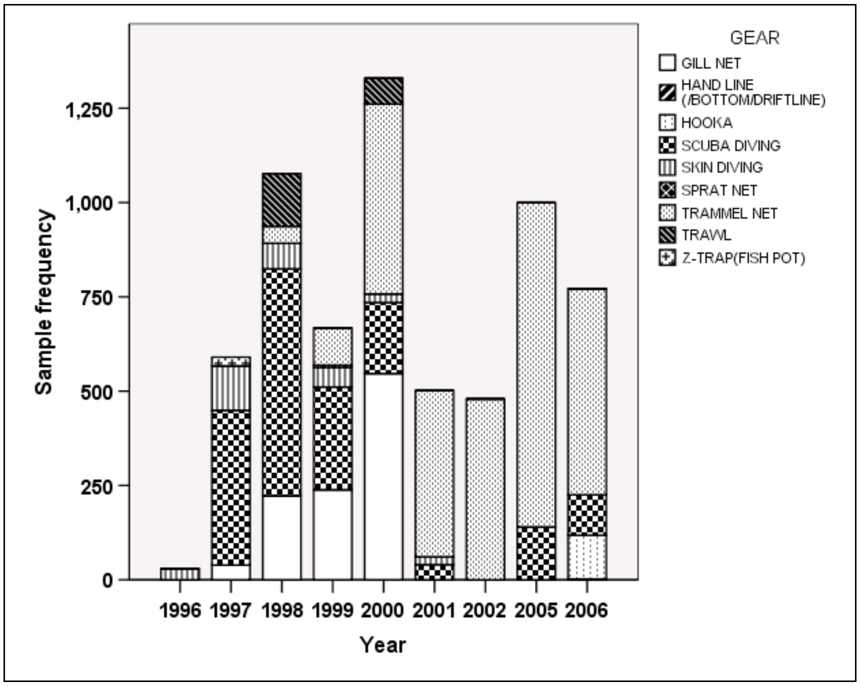


Figure 11: Frequency distribution of the total number of lobsters landed by gear used during the period 1996-2006.

4.8.6 Management

There is still not enough data on the fishery and this should be addressed urgently. The present management strategies will have to be improved and periodically assessed to evaluate their efficacy in curbing decline of the lobster stocks. A regional management approach is mandatory and the Caribbean Large Marine Ecosystem (CLME) project will address this problem to some degree. The Fisheries Division must also attract the attention it needs from the government and must be institutionally strengthened to efficiently execute its mandate.

Jamaica must address at least some of its national fisheries issues in order to play a more effective role in the overall regional management of lobsters. Other recommendations for increased management of the fishery could include:

- Ensure that current closed season is enforced as there is evidence of continuous landings.
- Increase the closed season to start in March and eventually February to protect recruited stock and females that have matured ovaries.
- Conduct data collection training exercises with data collectors.
- Collect one year concentrated data (catch and effort and biological) from at least two main landing sites ensuring that there are no gaps even during the closed season. This implies that fishery-independent data need to be collected.
- Based on evidence from Cuba and Mexico, the use of lobster casitas are not a solution for management. On a cautionary note, the Division should consider exerting its energy and resources into the enforcement of the regulations already in place for lobsters (especially minimum size and closed season) which will improve the status of the resources and also establish a more accurate recruitment index.
- Establishment of no take zones to protect recruited stock.
- Increase the minimum carapace length with increased enforcement.
- Reduction of fishing effort (limit entry) and begin to change the open access regime.

- Increased coverage in collecting biological, catch and effort and socio-economic data from fish processing plants.
- Collaboration with research institutions such as the University of the West Indies (UWI) to assist in data collection and analysis.
- Ongoing public education to sensitize fishers, other stakeholders and the general public on spiny lobster management.
- Encourage co management approaches in regulatory efforts
- Increase sampling on the Pedro Banks from quarterly to monthly otherwise ensure that sampling is carried out in the same month each year.

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Appendix 4: Report of the Shrimp and Groundfish Resource Working Group

Chairperson:	Suzuette Soomai, Trinidad and Tobago
Rapporteurs:	Yolanda Babb, Suriname (Shrimp)
	Colletta Derrell, Guyana (Shrimp)
	Pamila Ramotar, Guyana (Groundfish)
Consultants:	John Hoenig (Virginia Marine Institute of Science)
	Clay Porch, Todd Gedamke (US National Marine Service, Miami Laboratory)
	Lynn Waterhouse (Virginia Marine Institute of Science)
Absent:	Ms Lara Ferreira (Trinidad and Tobago) who was invited by the CRFM to assist in a technical capacity with the shrimp assessments.

A. OVERVIEW

1.0 Review of Inter-sessional activities

1.1 Shrimp

At the Second CRFM Scientific Meeting in 2006, Guyana conducted an assessment for the seabob (*Xiphopenaeus kroyeri*) and it was recommended that during the inter-sessional period a biological sampling programme be initiated to collect additional information to validate the 2006 assessment. It was also recommended that additional computerization of available sampling trip data should be completed. These activities were not completed due to insufficient data entry and field data collection staff.

It was recommended that at the Third CRFM Scientific Meeting in 2007, that Guyana and Suriname could conduct a joint assessment for *Farfantepenaeus subtilis* and *F. brasiliensis* similar to the assessment that was completed for Trinidad and Tobago and Venezuela at the Second CRFM meeting. The inter-sessional meetings that were recommended to prepare for this were not scheduled. It was discussed at this meeting that Guyana's seabob (*Xiphopenaeus kroyeri*) is being considered a priority fishery for assessment since it now contributes significantly to the total annual landings and exports of marine products.

1.2 Groundfish

At the Second CRFM Scientific Meeting, it was recommended that the whitemouth croaker, *Micropogonias furnieri*, be added to the list of species for future assessment. The data preparation for this species was not completed by Trinidad and Tobago during the inter-sessional period due to time constraints in filling data gaps and data for the species were not available for the meeting for assessment.

1.3 Management Developments

In Guyana, a Fisheries Advisory Committee (FAC) was formed in 2007.

In Suriname, the Ministry of Agriculture, Animal Husbandry and Fisheries has prepared an Agricultural Sector Plan for 2006 – 2010 that includes projects for the fisheries sector namely updating of legislation, establishment of a Fisheries Inspection Institute. In January 2007, Suriname implemented a vessel monitoring system (VMS) using the ARGOS system in an attempt to enforce the fishing zone regulations for fish trawlers. A designated landing site is currently being constructed for the artisanal fisheries in Paramaribo.

In Trinidad and Tobago, a new Marine Fisheries Policy was completed in 2007 and a new Fisheries Management Act to repeal the Fisheries Act of 1916 has been prepared in 2006 and is awaiting Cabinet approval.

2.0 General Review of Fisheries Trends throughout the Region

Suriname, Guyana and Trinidad and Tobago have substantial fisheries for the shrimp and groundfish resources of the Brazil-Guianas Continental Shelf. These resources are considered to be shared by all the countries on the continental shelf. In addition to these countries, Jamaica has a small shrimp fishery in the Kingston Harbour. Assessments have been conducted in the past under the FAO/WECAFC ad hoc Working Group on Shrimp and Groundfish Resources of the Brazil-Guianas Shelf and the CRFM. Species that have been assessed were the five shrimp species (*Farfantepenaeus notialis, F. subtilis, F. brasiliensis, Litopenaeus schmitti, X. kroyeri,*) and the main groundfish species (*Macrodon ancylodon, Cynoscion virescens,Cynoscion jamaicensis, Micropogonias furnieri*, *Lutjanus synagris, Nebris microps*). Results of assessments show that many of these species are fully to over-fished.

3.0 Review of Fisheries to be Assessed

3.1 Species and data available

Shrimp

Five species, *Farfantepenaeus notialis, F. subtilis, F. brasiliensis, X. kroyeri, Litopenaeus schmitti* were listed for assessment (CSM 2007: Document 1-A).

Guyana: *Xiphopenaeus kroyeri* (seabob), *Farfantepenaeus notialis* (pink shrimp), *F. brasiliensis* (pink spotted shrimp). Available data are monthly catch weight per size category collected at processing plants over the period 1998 – 2005.

Suriname: *Farfantepenaeus brasiliensis, F. subtilis* (brown shrimp). Available data are monthly catch in numbers and catch in weight (heads on and heads off), recorded by market category over the period 2000 – 2005.

Groundfish

Four species, *Lutjanus synagris*, *Macrodon ancylodon Cynoscion virescens, Micropogonias furnieri* were listed for assessment (CSM 2007: Document 1-A). Data for *L. synagris* and *M. furnieri* were not available at this meeting.

Guyana: *Cynoscion virescens* (sea trout), *Macrodon ancylodon* (bangamary), *Nebris microps* (butterfish).

Cynoscion virescens - catch and effort data were available from the industrial trawlers and artisanal gillnets for the period 1996 to 2006. Length data were collected for gillnets, seines (Chinese, pin) and cadell lines from 1996 to 2006 and from trawlers for 1998 to 2006.

Macrodon ancylodon - catch and effort and length frequencies for the period 1995 to 2006 from industrial trawlers and artisanal gillnets and Chinese seine.

Nebris microps - This species was not previously included in the list of species to be assessed. However, catch and effort and length frequencies for the period 1995 to 2006 were available at this meeting from industrial trawlers, artisanal gillnets and Chinese seine.

4.0 Review of Management Objectives and Management Strategies

Management objectives have been outlined in the national policy documents of the respective countries. Overall management objectives are to:

- Sustainably manage the resources,
- Maximise the long-term production of shrimp and groundfish by achieving MSY
- Contribute to employment, generation of foreign currency; maximisation of exports.

5.0 Fishery Data Analyses and Assessments

5.1 Groundfish

<u>The sea trout fishery in Guyana</u>

An assessment was completed to determine changes in the stock status based on three types of analyses: (a) estimation of total mortality rate using information on mean length (Gedamke and Hoenig 2006); (b) estimation of total mortality using length-converted catch-curve analyses and (c) estimation of trends in abundance based on standardized CPUE information.

<u>The bangamary fishery in Guyana</u>

A preliminary assessment was conducted to determine trends in the fishery from standardized CPUE indices generated using the general linear model (GLM).

<u>The butterfish fishery in Guyana</u>

A preliminary review of the available data was initiated to determine trends in the fishery from standardized CPUE indices from GLM. A report was not written for presentation.

5.2 Shrimp

<u>The seabob fishery in Guyana</u>

Trends in recruitment were observed by analyzing the CPUE by numbers of shrimp for the commercial classes for each month over the period 1998 – 2001. This was used to determine growth and to determine an appropriate closed season to protect recruitment of *X. kroyeri*.

<u>The penaeid shrimp fishery in Suriname</u>

Monthly catch in number per unit of effort for both species were used to establish patterns of yearly recruitment and to determine an approximate growth curve. Knowledge of recruitment and growth was used to recommend a closed season to protect recruitment of *P. subtilis.*

6.0 Recommendations

General recommendations (all items are considered high priority)

1. <u>Co-operation among countries</u>

- The species being assessed under this Working Group are shared by the countries on the Brazil-Guianas Continental Shelf. Future assessments should include data from other countries that are not members of the CRFM (Venezuela, French Guyana, Brazil). Venezuela was invited to attend the meeting but was unable to attend. The Working Group aims to conduct joint analyses for shrimp and groundfish between countries on the Brazil-Guianas continental shelf. It is recommended that CRFM enter into arrangements with these other states to facilitate their participation and exchange of data at future Scientific Meetings. It is also recommended that consideration be given to networking with the FAO/WECAFC ad hoc Working Group on Shrimp and Groundfish Resources of the Brazil-Guianas Continental Shelf.

2. **Computerization of data**

- Both Suriname and Guyana indicated that there is a considerable amount of biological and catch and effort data which have been collected and are still to be computerized. It is recommended that the CRFM can assist countries with this activity through the provision of resources in the respective fisheries departments to complete these activities in the inter-sessional period.

3. **Availability of data**

- Participants at CRFM Scientific Meetings need to bring all available information that may assist with the completion of assessments. In some cases national data were available within the Fisheries Department but the country participants were not allowed access to the information prior to the meeting.

4. **Observer Programmes**

- The observer programmes for the offshore trawl fleets need to be reinstated/established in the region to obtain information on fishing operations and total catches, including discards of commercial species, onboard vessels.

5. **Data Collection**

- On the respective national levels, all attempts must be made to obtain more representative statistical coverage of gear. Current sampling programmes are generally subject to severe staff constraints which negatively impact the data collection programmes both in terms of the volume of data and the continuity over time.

6. **Data Documentation**

- Considerable time was still spent trying to understand the data at this meeting and it is recommended that improving the data sets should be addressed in the inter-sessional period. There is still the need to have more communication between the consultants and the species rapporteurs in the inter-sessional period. A standard format for data files must be decided on to facilitate easy interpretation of data at the meeting and documentation needs to be improved.

Specific Recommendations

Groundfish

1. **Species to be Assessed**

- The list of groundfish species for assessment should be expanded to include additional species that are common to the countries exploiting the resources of the Brazil-Guianas Continental Shelf. Specifically, it is recommended that *Cynoscion acoupa, Nebris microps* and *Micropogonais furnieri* should be included in the list of species to be assessed at next year's meeting. A preliminary analysis of *N. microps* was initiated at this meeting and should be finalized at next year's meeting.

2. **Collection of Otoliths**

- Collection of age data from otoliths is recommended to supplement length data and to provide more reliable growth parameters for fish species for use in analyses. This activity should be given high priority within countries of the Working Group.

Shrimp

1. **Species to be Assessed**
   - A joint analysis for the seabob fishery should be conducted by Suriname and Guyana at the next Scientific Meeting.

2. **Effort Data**
   - For the seabob fishery in Guyana, effort data need to be extracted from logbooks kept at the shrimp processing plants.

3. **Biological Data**
   - For shrimp in Guyana and Suriname, length frequency data need to be collected.

4. **Economic Data**
   - For Guyana and Suriname, economic data such as price per pound for the various market categories should be documented over the course of a year in the first instance.

B. FISHERIES REPORTS

1.0 Guyana Seatrout (*Cynoscion virescens*) Fishery

1.1 Management Objectives

The Draft Fisheries Management Plan of Guyana states that the objectives for Sea trout management are:

- To maintain the stock at all times above 50% of its mean unexploited level.
- To maintain and improve the net income per fisher at a level above the national minimum desired income.
- To include as many of the existing participants in the fishery as is possible given the biological, ecological and economic objectives listed above.

1.2 Status of Stocks

The catch per day of trawlers has fluctuated with little trend since 1996, suggesting that the recruitment of young seatrout to the fishery has generally remained constant during the time (figure 1). Results of the assessment suggest a high fishing mortality rate, particularly on younger fish, which may exceed the level that maximizes the yield per recruit (figure 2). The catch per day from gillnet vessels has declined in recent years, which suggests that too many young fish are being caught by the trawl and other inshore fisheries to sustain the adult population of seatrout. This condition, if allowed to continue, may lead to a decline in recruitment.

1.3 Management Advice

The adult seatrout population appears to have been reduced to levels well below 50% of the unexploited level, indicating that the first management objective above has not been met. There were data gaps and other uncertainties with regards to the growth parameters for seatrout that influenced the ability of the assessment to give good results. In view of this, more specific management advice cannot be given at this time. It is therefore recommended that the precautionary approach be adopted and the harvesting of seatrout should be reduced.

1.4 Statistics and Research Recommendations

1.4.1 Data Quality

- Catch and effort data quality needs to be improved. The on-going collection of catch, effort, and size frequency data should be expanded to cover all months, gear types and areas where fishing is occurring (this information is necessary to develop total catch and CPUE series).
- This assessment used catch and effort data from 1996 – 2006. However catch and effort data were collected prior to 1996. These data records from the earlier surveys need to be reviewed and computerized, so that longer time series may be examined which will result in more informative assessments.

1.4.2 Research

- Ototliths (ear bones) and scales should be collected from a sample of fish for a feasibility study on determining age. Assuming that this is successful, it will be possible to better characterize what ages are being exploited and to develop a more suitable growth curve.

- The observer programme for the trawl fleet needs to be reinstated to obtain information on fishing operations and total catches, including discards of commercial species, onboard vessels.

- There should be collaboration with countries such as Suriname, Venezuela and Brazil for stock assessments since seatrout is considered a shared stock.

1.5 Stock Assessment Summary

The analysis utilized recent (1996-2006) length and catch per unit effort (CPUE) levels for artisanal gillnet, Chinese seine and trawl fleets operating in Guyana. Biological parameters were obtained from a previous unpublished assessment in 2003 for the species and from Charlier *et al*. (2000). The assessment was based on three types of analyses: (a) a mean size model that observed growth using the length frequency information (Gedamke and Hoenig 2006); (b) length-converted catch-curve analyses and (c) standardized CPUE information.

(a) Mean size Model:
Mean lengths from the trawl samples suggested that selection of fish from as early as age 1 was common. The truncated length composition data used in this model suggest a highly exploited population. However, the exploitation rate may be somewhat over-estimated because larger fish may be able to evade the trawls and also migrate further offshore than most trawls operate. They are also somewhat uncertain owing to the lack of definitive growth parameters.

(b) Length-converted catch-curve Model:
The length frequency data from the trawl samples were converted to relative age by use of the two sets of growth parameters: those from the previous assessment (CRFM 2004) (K=0.3, Linf=90) and those from (Charlier *et al*. 2000) (K=0.39, Linf=95.8).

The results indicated mortality rates that were similar to the values estimated by the mean length method using the same data and growth parameter estimates.

(c) Standardised catch per day.
Catch per day was standardized to account for unbalanced and incomplete sampling across months, regions and years by use of the general linear model (GLM). The standardized trawl and gillnet catch per day series are shown in Figure 1. The results suggest that the availability of younger fish to the trawls has remained fairly constant since 1998 except for a spike in 2005. However, the availability of larger fish (estimated at age 5 and older) to the gillnets appears to have decreased after 1999. This suggests that growth overfishing is occurring (where too many sea trout are caught before they have had a chance to grow to an optimal size), but not necessarily recruitment overfishing (since there is no evidence that the abundance of young animals has declined despite the declining availability of larger fish).

1.6 Special Comments

Alternative data sources for monitoring gillnets need to be developed. Either samples need to be aged using hard parts, such as scales or otoliths, or more detailed catch and effort monitoring needs to be conducted.

Trawl length frequency provides useful information on the stock and therefore length frequency sampling from trawl should be increased.

1.7 Policy Summary

To manage, regulate and promote the sustainable utilization of Guyana's fishery resources for the benefit and safety of all stakeholders in the sector and the nation as a whole.

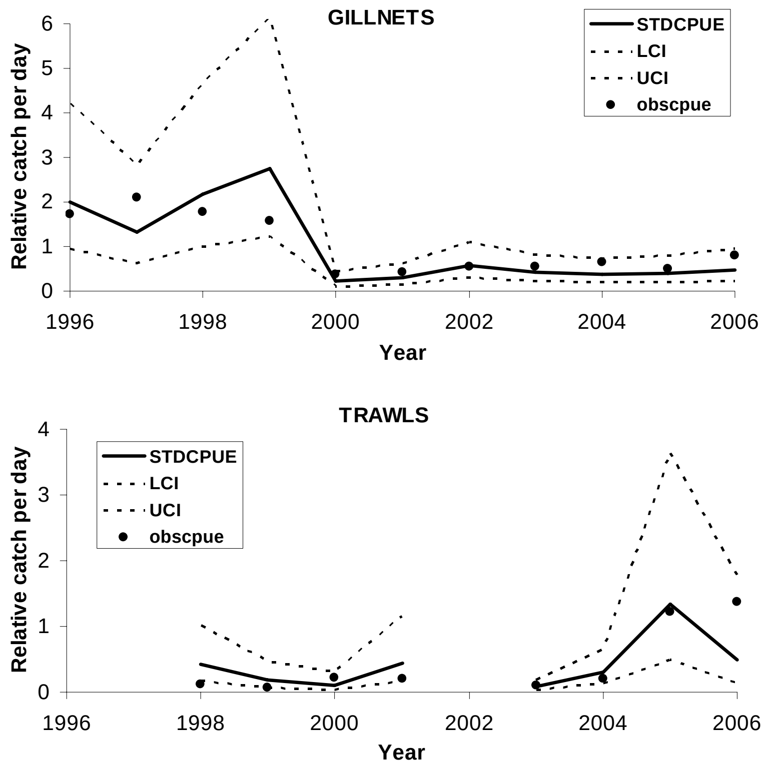

Figure 1: Standardized catch per day for gillnets (top) and trawls (bottom). The two series were normalized to have the same scale by dividing the annual values for each series by the average for that series. STD CPUE = standardized catch per unit effort; dashed lines indicate 95% confidence intervals; obscpue = observed catch per unit effort.

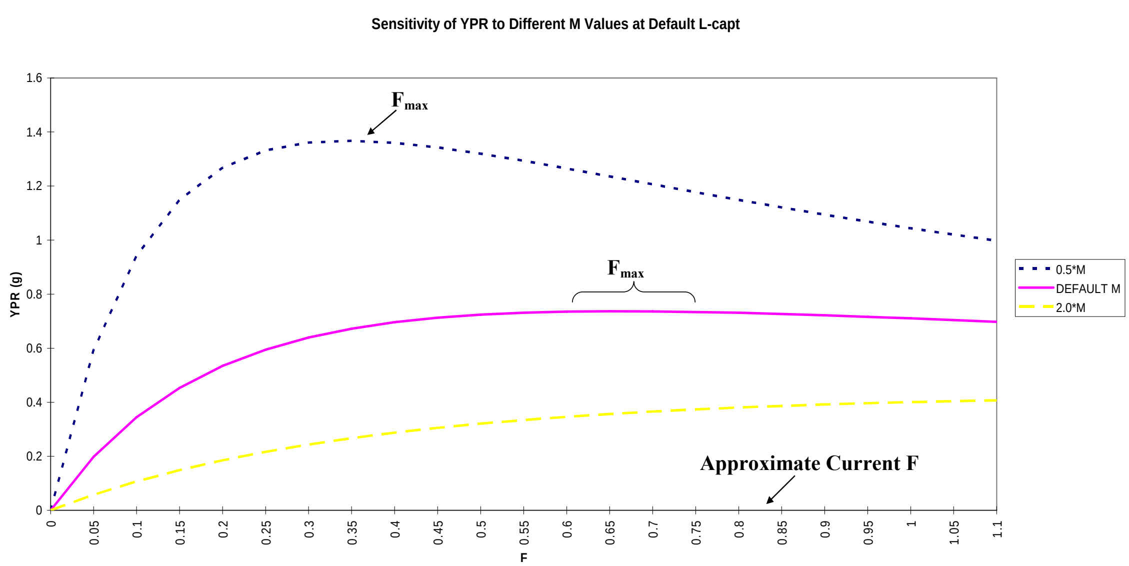

Figure 2: Yield per recruit analysis for sea trout in Guyana using parameters used from the current analysis (K= 0.3938, L_{inf} = 95.8, M= 0.59 yr^{-1}, a = 0.0000118, b= 3.0, Z = 1.42). M was varied by multiplying by 0.5 or 2.0.

1.8. Scientific Assessments

1.8.1 Description of the fisheries

The Inshore Artisanal Fishery consists of vessels ranging in size from 6 to 15 meters propelled by sails, outboard or inboard engines and using gear that include pin seines, Chinese seines (a fyke net), cadell lines, drift seines and circle seines (modified gillnets). The larger vessels have ice boxes and go on fishing trips that last as long as 12 or more days. Smaller vessels may or may not have ice boxes and their operations are either tidal or diurnal. Except for the large drift seine vessel, which may or may not be decked, most vessels are flat bottomed dory type with little draft which affords great manoeuvrability over shallow muddy and sandy bottoms.

Pin seines or beach seines are 2 m high and up to 2,000 m in length with a stretched mesh size of 9 cm or less. The net is set at high tide in the inter-tidal zone. During the ebbing tide fish are trapped and then retrieved from the mud flats. The catch includes mullet/queriman (*Mugil sp*.), snook (*Centropomous sp*), bangamary (*Macrodon ancylodon*), croaker (*Micropogonias furnieri*) and catfishes of the family *Ariidae*. About 83 vessels are involved in pin seine fishing.

Chinese seines are funnel-shaped nets 16 m long and 4-6 m wide at the mouth end. Their mesh size gradually tapers from the mouth end (8 cm) toward the bag end (1 cm). The net is attached to poles and set on mud banks along the coast, in rivers and particularly at river mouths. Fish and shrimp are swept into the bag of the net by the tidal currents. Each boat operates between one and ten nets. The catch is normally made up of seabob (*Xiphopenaeus kroyeri*), whitebelly shrimp (*Nematopalaemon schmitti*), bangamary (*Macrodon ancylodon*), butterfish (*Nebris microps*) and catfishes, mainly of the family *Ariidae*. An undetermined amount of immature fish is caught and in most cases discarded. The mortality of these fish is 100%. Over 400 vessels are involved in Chinese seine fishing.

Gillnets (polyethylene) vary in length from 1,000 to 1,600 m and are 4 m deep with a stretched mesh measure of 20 cm. Nets are set and hauled manually from the boats. The catch consists mainly of gray snapper (*Cynoscion acoupa*), seatrout (*Cynoscion virescens*), bashaw (*Cynoscion jamaicensis*), pagee (*Lobotes surinamensis*), tarpon (*Tarpon atlanticus*), gillbacker (*Arius grandicassis*), mackerel (*Scomberomorus maculates*) and sharks (*Carcharhinus spp*.) (Chakalall and Dragovich 1979). Some 400 vessels are involved in gillnet fishing.

Modified versions of the gillnet approximately 300 m in length, made of nylon, and with smaller mesh sizes (15 cm), are being used by some operators in the near shore areas to catch mainly catfishes (*Arius spp*.) but younger stages of grey snapper (*Cynoscion acoupa*) and seatrout (*Cynoscion virescens)* also occur in the catch. Immature fish are discarded. About 200 vessels are involved in gillnet (nylon) fishing.

Another version of the gillnet made of nylon and called a circle seine is used in the Corentyne River in Berbice. The average length is 300 m with small stretched mesh sizes. The catch consists of laulau (*Arius spp*), silver bashaw (*Plagioscion spp)*, and highwater (*Hypophthalmus edentatus*). Approximately 8 vessels are involved in circle seine fishing.

Activity in the Inshore Artisanal Fishery occurs along the Coastline. Guyana has ten administrative regions (Figure 3). The effects of the trawl fishery on the demersal fin fish stocks in regard to by-catch resulting from shrimping (prawns and seabob) and fin fish as a result of direct fishing would have to be taken into consideration when looking at expansion. In like manner the effects of trawling for seabob would have some bearing on seabob and whitebelly shrimp available to the chinese seine operators and vice versa.

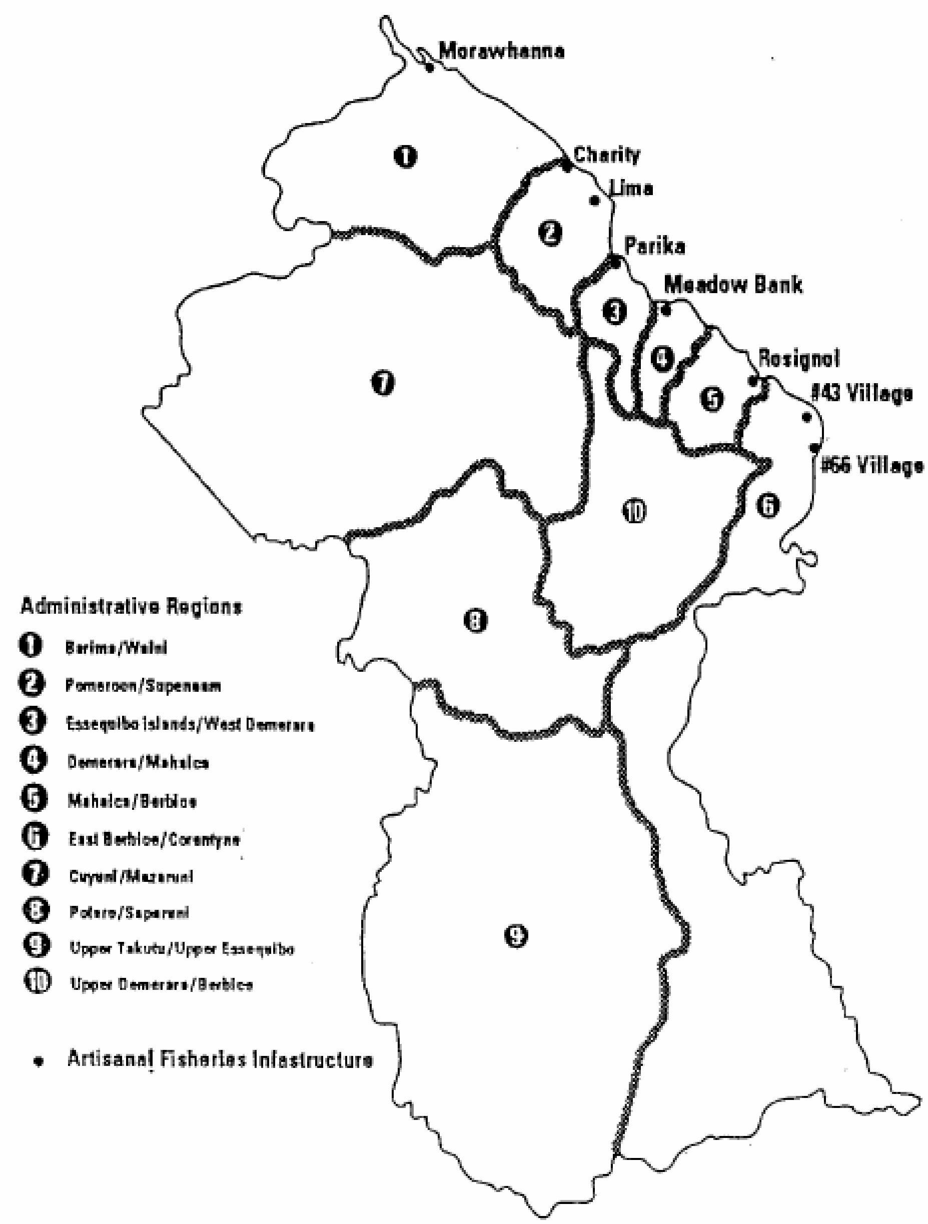

Figure 3: Map showing the ten administrative regions in Guyana

The data collection programme is a stratified random programme. Stratification is done by vessel/gear type. The landings, employment and value of the catch were important factors that led to this type of stratification. This determined the number of vessels to be sampled per month per gear type.

At the beginning of every month, sampling schedules are prepared in the three Regions for data collection. A total of 82 vessels are chosen to be sampled for data. These vessels are randomly selected from landing sites in the Regions. They comprise 20 chinese seine, 17 gillnet nylon, 4 cadell, 15 gillnet (outboard), 6 gillnet (inboard), 4 pin seine, 3 handlines and 2 traps for the artisanal fishery and 6 seabob and 5 prawns for the industrial fishery.

The vessels sampled in Region 4 are all the industrial vessels and forty-two artisanal. In Regions, six and two the number of vessels sampled is 13 and 14 respectively.

The number of vessels being targeted for data collection has been reduced due to a manpower shortage. Only 65 vessels are being sampled per month. Sampling is done three days per week Tuesday to Thursday and at least two trips are scheduled per day. The number of vessels targeted per trip would depend on the landing site being targeted, the number of data collectors and the number of vessels at the site.

Catch and effort and biological data are collected from the vessels selected randomly at the landing sites.

1.8.2 Overall Assessment Objectives

The main objective was to analyse the available data on the Artisanal Fishery and to build a stock assessment approach to give management advice for this fishery. Data exist to estimate the catch and fishing effort by each gear. In addition a biological sampling programme was conducted during the period of 1996-2006 to collect length frequency data on the species. Catch curves were fitted to the data to obtain estimates of total mortality rate. An evaluation was done to determine if there were changes in stock status and total mortality (Z) based on changes in mean length and size frequency composition through a generalization of the Beverton and Holt method developed by Gedamke and Hoenig (2006). A standardized Catch per Unit Effort (CPUE) index was developed to track changes in relative abundance over time.

1.8.3 Data Used

Ten years of data collected by the Fisheries Department was used for the period of 1996-2006 as described below.

Name	Description
Catch sampling	Landings were sampled from both artisanal vessels and industrial vessels from 1996-2006 based on a sampling program.
Trip Interview programme	Trip catch and effort sampling for 1996 – 2006 provides total catch and effort.

1.8.4 Assessment 1

<u>1. 8.4 .1 Objective</u>

The objective was to estimate the total mortality rate (Z) using a length-converted linearized catch curve.

<u>1. 8.4 .2 Method/Models</u>

The method used was the length-converted linearized catch curve model (see Sparre and Venema 1992, pg 126). Length conversion to age requires a growth model. Parameters for the growth model, obtained from previous assessments and Charlier *et al*. (2000), were considered approximate.

Table 1: Parameters for Von Bertalanffy growth model, length-weight conversion and natural mortality used in the assessment to convert length to age in the catch-curve method, used in the mean length method, and in the yield-per-recruit model. Natural mortality was estimated from Jensen's (1996) "empirical" equation based upon the assumed growth parameters.

Growth Model Parameters (Previous Assessment)			
K ($year^{-1}$)	L_∞ (cm)	T_0	
0.3	90.0	0	
Length-Weight Conversion		**Natural Mortality**	
A	B	M	
1.18E-05	3.00	0.45	

Growth Model Parameters (Charlier *et al.* 2000)			
K ($year^{-1}$)	L_∞ (cm)	T_0	
0.39	95.8	-0.15	
Length-Weight Conversion		**Natural Mortality**	
A	B	M	
1.18E-05	3.00	0.56	

1. 8.4 .3 Results

Sample data for the period of 1996-2006 from the trawl fishery were used to obtain length frequencies. These frequencies were binned into 5 cm intervals. A lower class boundary of 30 cm was used. The largest size classes were truncated to eliminate classes with less than two fish observed. The size frequency pattern for trawls appears to be consistent with knife edge selection as shown in figure 4.

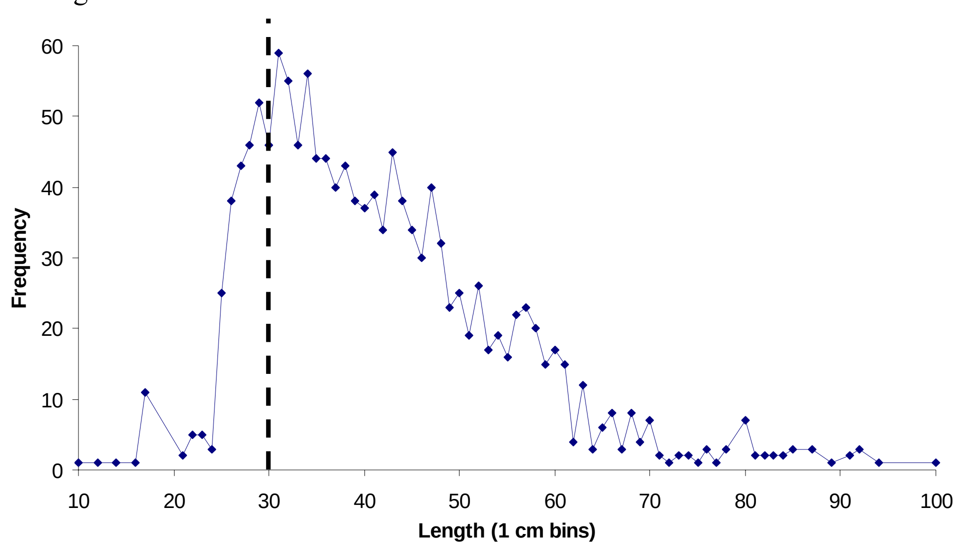

Figure 4: Cumulative catch of all individuals measured in the trawl catches to determine the length at full vulnerability (L_c) to the gear (indicated by the dashed line).

The downward trend on the right can be used to fit the catch curve. This assumes that the downward trends to the right of the mode are due to mortality and growth alone. The left of the mode was not used because of the effect of selectivity.

Estimates of mortality derived using the growth parameters from the previous assessment *(K=0.3, Linf=90)*

Figure 5 shows the log-abundance plotted against the relative age as calculated from length for all years combined. The growth parameters were taken from the previous assessment. The slope of the line was 0.79 and is an estimate of the total mortality rate Z. The R^2 goodness-of-fit statistic was 0.97 and implies the line explains 97% of the variation in the abundance index (i.e., the length frequency). Total mortality estimates from length-converted catch curves fitted to data from individual years range from 0.44 to 1.7 year^{-1}, with an overall average of 0.93 (Table 2).

An estimate for natural mortality was obtained from Jensen's (1996) empirical equation of 0.45 yr^{-1}. Subtracting the natural mortality from the estimated Z gives an estimate of the fishing mortality, F, which is in this case 0.79 - 0.45 = 0.34 year^{-1}.

Estimates of mortality derived using the growth parameters from Charlier *et al.* (2000) *(K=0.39, Linf=95.8)*

Figure 6 shows the log-abundance plotted against the age as calculated from length for all years combined. The slope of the line was 1.22 and the R^2 goodness-of-fit statistic was 0.98 The slope of the line gives an estimate of the total mortality (Z) while the R^2 goodness-of-fit statistic implies the line explains 98% of the variation in the abundance index (i.e. the length frequency). Total mortality estimates from all years range from 0.68 to 2.4 year^{-1}, with an overall average of 1.36 (Table 3)

The fishing mortality, F, in this case is 1.22 - 0.56 = 0.66 year^{-1}. The estimate for natural mortality was obtained from Jensen's (1996) empirical equation.

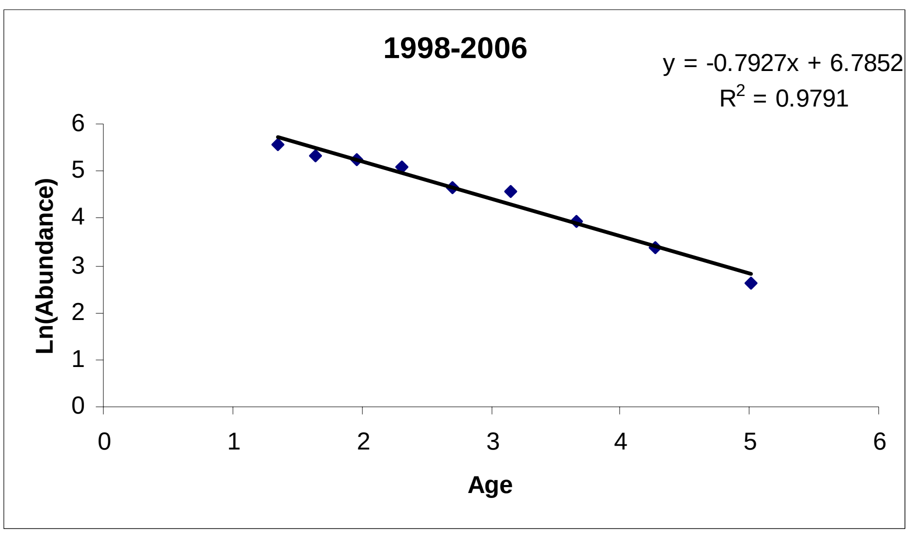

Figure 5: Length converted catch curve. The slope is 0.792 and should be equal to the average total mortality for the stock across all ages. The growth parameters were taken from the previous assessment (growth rate k = 0.30 year^{-1}, Linf = 90 cm.)

Table 2: Estimated mortality for seatrout from 1998-2006, assuming the growth rate is k = 0.3 $year^{-1}$ and L_∞ = 90 cm. Growth parameters are from the previous assessment.

Year	Z (mortality)	Standard error	*Upper 95%*	*Lower 95%*	No. of fishes
1998	0.889789227	0.267178225	1.54355079	0.23602766	254
1999	0.623376848	0.190079898	1.07284439	0.17390931	193
2000	1.656555892	0.405628745	2.78276184	0.53034995	109
2003	0.441431335	0.0840019	0.63514006	0.24772261	202
2004-2006	0.957586097	0.172315516	1.40053723	0.51463496	73
average Z	0.91374788				
average S	0.401018435				

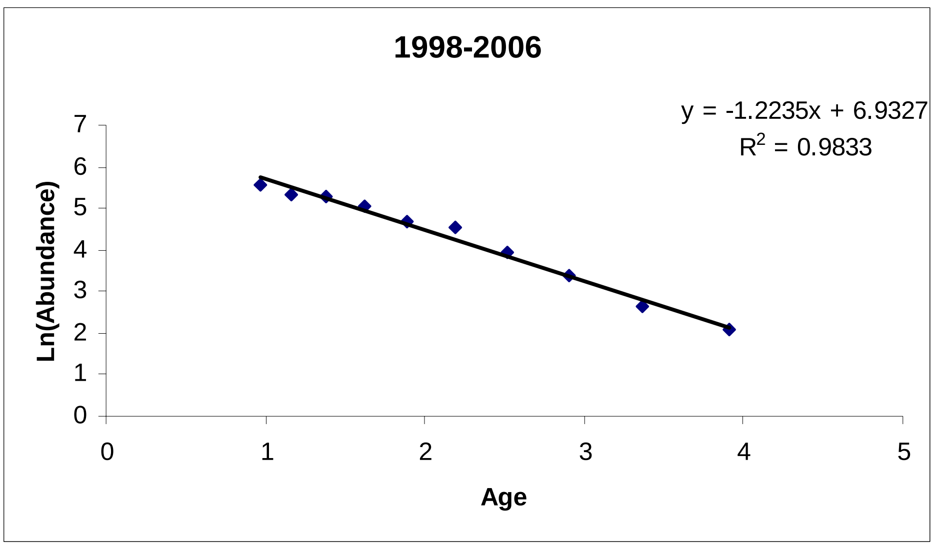

Figure 6: Length converted catch curve. The slope, 1.22, should be equal to the average total mortality for the stock across all ages. The growth parameters are taken from Charlier *et al.* (2000).

Table 3: Estimated mortality for seatrout from 1998-2006, assuming the growth parameters in Charlier *et al.* (2000) (growth rate k = 0.39 $year^{-1}$ and L_∞ = 95.6.cm.)

Year	Z (mortality)	Standard error	Upper 95%	Lower 95%	No. of fishes
1998	1.344457178	0.3926527	2.30524372	0.38367063	254
1999	0.929020172	0.29389675	1.62397555	0.23406479	193
2000	2.422590104	0.599878284	4.08811923	0.75706098	109
2003	0.68724817	0.129803792	0.98657625	0.38792009	202
2004-2006	1.420646176	0.250171877	2.06373346	0.77755889	73
average Z	1.36079236				
average S	0.25645749				

It was not possible to conduct a similar analysis for gillnets, although the attempt was made. Firstly there are too few points to the right of the mode to obtain a good estimate of the slope. Secondly, the selectivity pattern of the gear recruits animals at a larger size and the mode itself lay at or near the mean asymptotic length. The implication is that the downward slope is the result of variation in asymptotic size, not age. Hence it is not possible to estimate mortality from gill net length frequency data using this method.

1. 8.4 .4 Discussion

The estimates of total mortality were variable but high. This suggests that the recent fishing mortality for seatrout is close to or above natural mortality. This implies that the stock is being fished at or near the maximum sustainable yield (MSY). The estimate of fishing mortality and stock status is clearly dependent on the natural mortality estimate, which is only approximate and based on Jensen's "empirical" equation which is based upon the assumed growth parameters (see table 1). The catch curve method uses the growth parameters in converting the length to age. The results of this analysis, however, are based on relatively uncertain estimates of the von Bertalanffy growth parameters.

To improve the reliability of the results, future studies should be focused on developing an empirical age-growth relationship. Otolith and scale samples should be taken for this purpose. These samples should be taken from trawls and gillnet fisheries representing the entire age range of the population.

Length data for the years 2001-2002 were not used because the sample sizes were very small. The sample sizes for 2004-2006 were slightly larger, but insufficient for annual estimates and therefore combined.

Seatrout from trawlers are considered bycatch, and only make up a relatively small proportion of the catch of this species. Information is needed on these discards at sea.

The length frequency data by themselves cannot be the basis of a full assessment and should be supported by age data. Also assessments using catch and effort data require a long time series and can show significant changes in both catch and effort over time. Such data can be used to fit relevant stock assessment models.

1.8.5 Assessment 2

1. 8.5.1 Objective

The objective was evaluate changes in stock status and total mortality (Z) based on changes in mean length and size frequency composition through the Beverton and Holt (1956, 1957) mean length mortality estimator and the Gedamke and Hoenig (2006) method. Estimates of total mortality were then used in conjunction with the estimates of natural mortality and a yield per recruit model to evaluate stock status.

1. 8.5.2 Method/Models

Size frequency data from 1998 through 2006 were evaluated from both the trawl and gillnet fisheries of Guyana to determine the most appropriate data set to be used in a mean length analysis. Mean lengths were then calculated for each year and total mortality was estimated for each year through the Beverton-Holt estimator and a single estimate of total mortality generated by the Gedamke and Hoenig (2006) method. The derivation of the Beverton-Holt estimator begins by assuming deterministic asymptotic growth as described by the von Bertalanffy equation

$$L_t = L_\infty(1-\exp(-K(t-t_o))) \quad (1)$$

where L_t is the length at age t, and L_∞, K and t_o are the growth parameters. Also assume that the instantaneous total mortality rate is constant over time and over age for all ages $t > t_c$, where t_c is the age at which animals are fully vulnerable to the fishery and to the sampling gear. Denote this mortality rate by Z yr^{-1}. Further, assume that recruitment is continuous over time at constant rate R. The mean length of those animals above the length L_c corresponding to the age t_c is

$$\overline{L} = \frac{\int_{t_c}^{\infty} N_t L_t dt}{\int_{t_c}^{\infty} N_t dt} \tag{2}$$

where L_t is given by (1) and $N_t = R \exp(-Z(t-t_c))$. Performing the integrations in (2) and simplifying yields

$$\overline{L} = L_\infty(1 - \frac{Z}{Z+K}\exp(-K(t_c - t_o))) \quad . \tag{3}$$

Equation (3) is easily solved for the mortality rate. Thus,

$$Z = \frac{K(L_\infty - \overline{L})}{\overline{L} - L_c} \tag{4}$$

Note that the parameter t_o has been eliminated from the solution through algebraic manipulation using equation (1).

There are six assumptions behind this method.

1) Asymptotic growth with known parameters K and L_∞ which are constant over time.
2) No individual variability in growth.
3) Constant and continuous recruitment over time.
4) Mortality rate is constant with age for all ages $t > t_c$.
5) Mortality rate is constant over time.
6) Population is in equilibrium (i.e., enough time has passed following any change in mortality that mean length now reflects the new mortality level).

Gedamke and Hoenig (2006) developed an extension of the Beverton-Holt length-based mortality estimator for use in non-equilibrium situations. This method is attractive because it still only requires minimal data that are commonly available and it does not require the assumption that catch rate is proportional to abundance. It allows for the broader application of a mean length analysis approach by removing an equilibrium assumption that is typically difficult to meet in real world situations. In addition, the transitional form of the model allows mortality estimates to be made within a few years of a change I mortality rather than having to wait for the mean lengths to stabilize at their new equilibrium level. In other words, as soon as a decline in mean lengths is detected, this model can be applied and the trajectory of decline can be used to estimate the new Z and how mean lengths will change over time. The method is described in detail in Gedamke and Hoenig (2006). However, for this application there is only one significant difference between this approach and the Beverton-Holt estimates. The Gedamke and Hoenig (2006) approach uses maximum likelihood estimation and information on mean lengths and sample sizes from all the years being considered to generate weighted estimates of total mortality for time periods (i.e. multiple years) rather than providing a mortality estimate for each year.

1. 8.5.3 Results and Discussion

Size frequency data for seatrout from the trawl fishery were available from 1998 through 2006. Sample sizes ranged from 12 to 413 fish being measured in a year. An examination of the length frequency data from the fisheries of Guyana showed that the selectivity of the two primary gears (gillnet and trawl) were considerably different (Figure 7). The gillnet fishery is capturing only a few small individuals with a majority of the catch within 20 cm of their estimated maximum size (L_{inf}). The trawl fishery, on the other hand appears to have close to a knife edge selection with full vulnerability (L_c) around 30 cm and then a gradual decline in the abundance of larger individuals (Figure 4). Although the size frequency in the trawl fishery suggests that catchability of larger individuals may be reduced (via greater swimming speeds and ability to escape the path of the gear) the selectivity pattern of this gear is the most applicable of the available data for length frequency analysis.

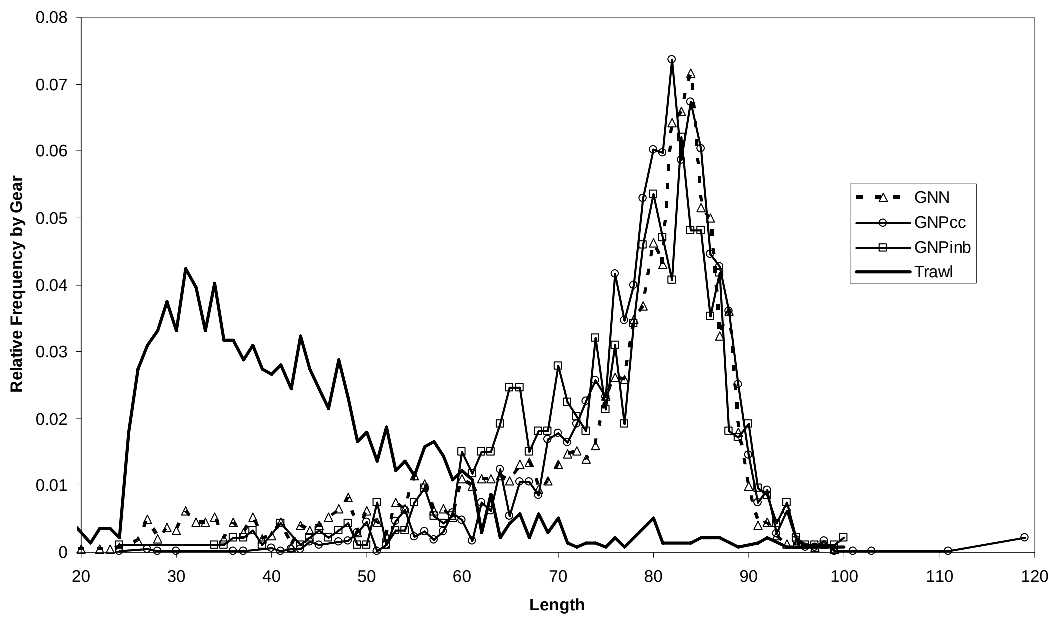

Figure 7: Size-frequency distribution of catch from the trawl and gillnet fisheries of Guyana (GNN=gillnet nylon, GNP cc= gillnet cabin cruiser poly, GNP inb = gillnet inboard poly).

Annual mean lengths with corresponding confidence intervals were calculated from all measured seatrout that were greater than the L_c of 30 cm (Figure 8). There was no apparent trend in mean lengths over time with calculated means ranging from 38 to 60 cm. The lack of an obvious trend suggests that there is no strong indication of a change in mortality having occurring during the time frame being analyzed. Total mortality estimates from the Beverton-Holt approach differed depending on the growth parameters used in the model. Using growth parameters from Charlier *et al.* (2000) of K= 0.39 and L_{inf} = 95.8, total mortality estimates ranged from 0.45 to 2.9 yr^{-1} (Figure 9). Using parameters from the previous assessment (k=0.3, L_{inf} = 90 cm) total mortality estimates ranged from 0.29 to 2.02 yr^{-1} (Figures 9 and 10).

The Gedamke and Hoenig (2006) method was then explored, however with no significant contrast in the data; the model was unable to detect a change in mortality. The model was constructed assuming that there was no change in mortality in the time period being analyzed (i.e.

all of the mean length data from 1998-2005 was weighted by the sample size for each year to generate a single estimate of total mortality). This aggregated analysis estimated a total mortality of 1.22 yr^{-1} (Figures 9 and 10).

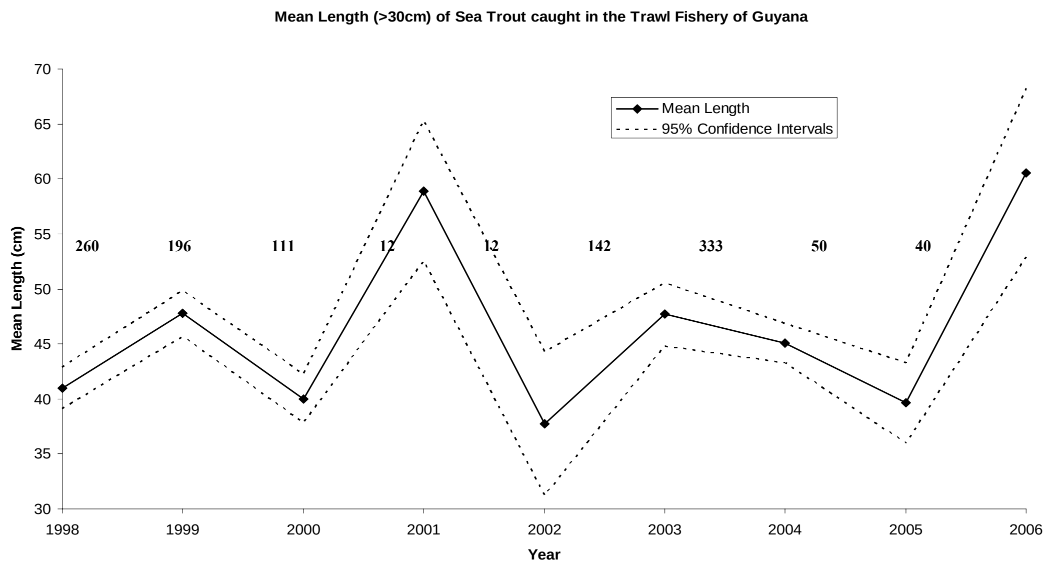

Figure 8: Mean length of individuals greater than size full vulnerability to the gear (30 cm from Figure 7). Sample sizes for each year are indicated by the blue number and 95% confidence intervals have been indicated by the dashed red line.

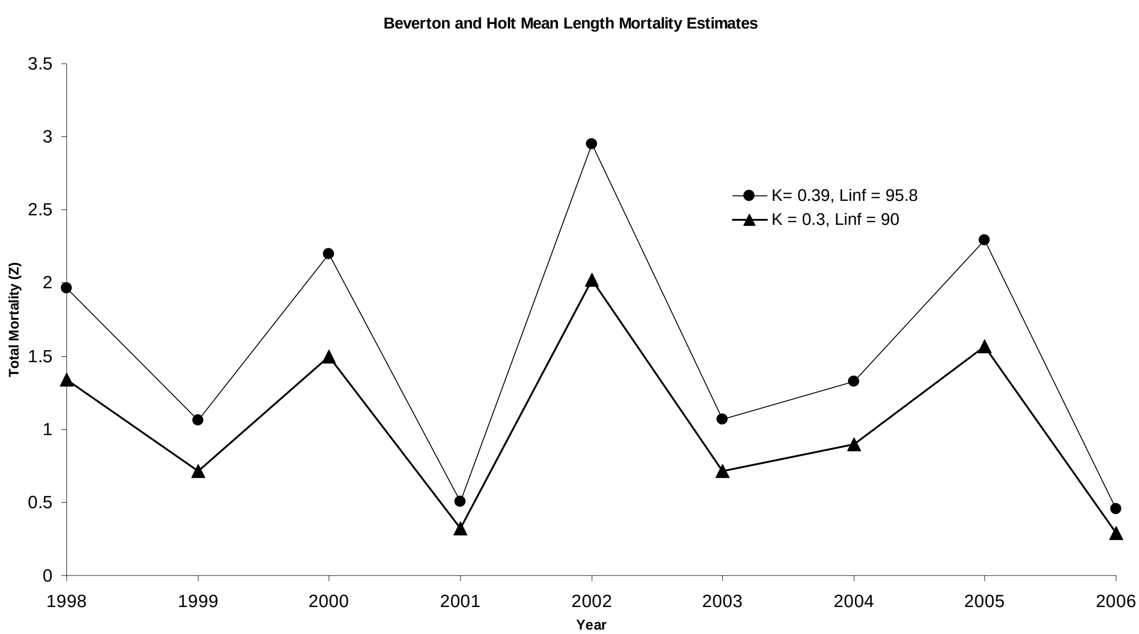

Figure 9: Annual estimates of total mortality from the Beverton Holt mean length mortality estimator given growth parameters from Charlier *et al.* (2000) and a previous assessment. Note that samples sizes were the lowest for the most extreme values in 2001 and 2002 (see Figure 8).

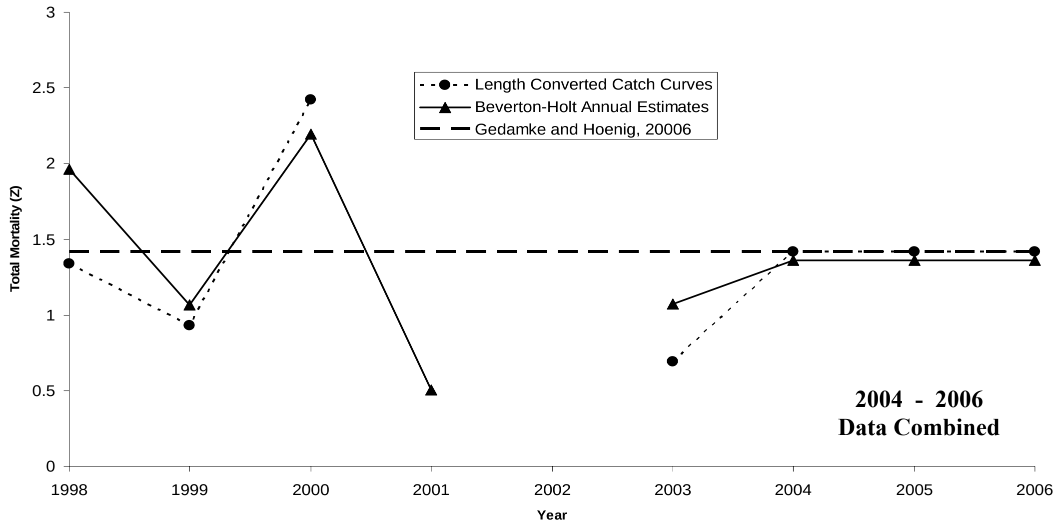

Figure 10: Comparison of total mortality estimates from three different techniques. Growth parameters from Charlier *et al.* (2000) (K=0.39 and L_{inf} 95.8 cm) were used in the analysis.

The yield per recruit model using growth parameters from the previous assessment (k=0.3, L_{inf} = 90 cm) and an assumed natural mortality of 0.46 yr^{-1} estimated an F_{max} of 0.55 yr^{-1} (Figure 11). This is approximately the same as the estimated F given the parameters of the analysis: Z (0.97) - M (0.46) = F (0.51). Using the growth parameters from Charlier *et al.* (2000), F_{max} was approximately 0.65 but not as well defined with a gradual peak between 0.60 and 0.70 yr^{-1}. Using the Charlier *et al.* parameters F is estimated to be 0.83 which is still above the estimated $F_{max.}$ Both sets of parameters result in estimates that indicated that F is at or above F_{max} and growth overfishing is occurring. The interpretation of these results, however, should strongly consider the uncertainty surrounding the growth parameters and the importance of these parameters in the analysis.

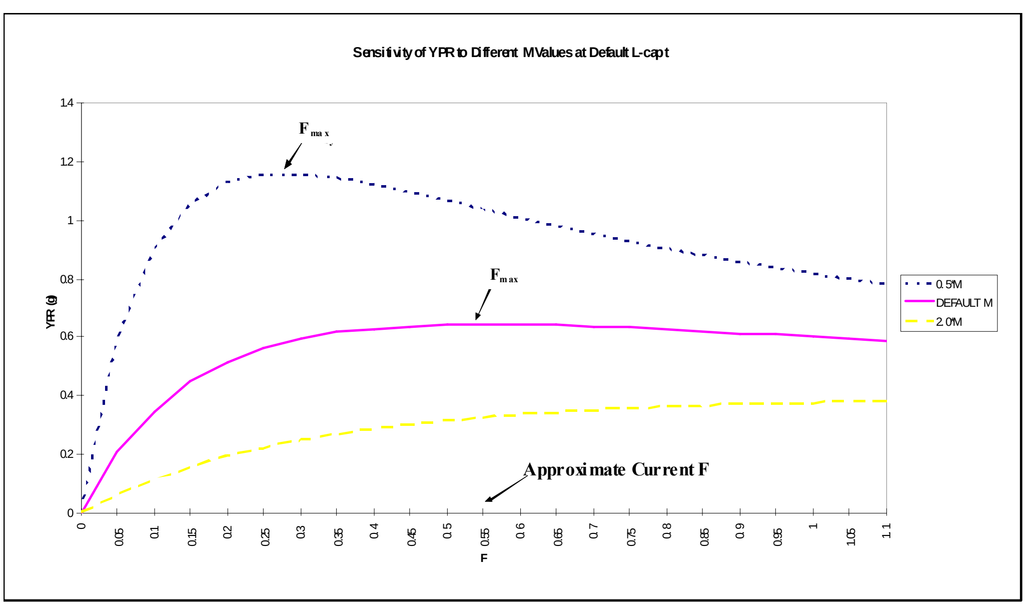

Figure 11: Yield per recruit analysis for seatrout in Guyana using parameters from the previous assessment (K= 0.3, L_{inf} = 90, M= 0.46 yr^{-1}, a = 0.0000118, b= 3.0, Z = 0.97 yr^{-1}).

1.8.6 Assessment 3

1.8.6.1 Objective

The objective was to develop a standardized Catch per Unit Effort (CPUE) index.

1.8.6.2 Method/Models

The most complete catch data came from the trawl and gillnet fisheries between 1996 and 2006. Regions 1 and 2 were sparsely sampled and believed to be very similar to those operating off region 3; therefore the three regions were combined (see Figure 3 for regions). Separate indices were developed for gillnets and trawls because the size frequency distributions for these gears are very different (trawls operate closer to shore and tend to catch younger, smaller animals, see Figure 7). As discussed earlier, there are three main categories of gillnets: 6-inch-stretch nylon deployed mostly by small outboard vessels (GNN), 8-inch-stretch polyethylene deployed by cabin cruisers (GNPcc) and 8-inch-stretch polyethylene deployed by larger inboard vessels (GNPinb). The length frequency distributions for these three gear classes were very similar, which suggests they select for a similar age range of animals. For this reason, separate indices were not developed for each gillnet category. It was noticed, however, that the magnitude of the catch and number of samples varied among gillnet categories, as well as by month and region of the coast. Hence, it may happen that a simple nominal catch per day index (created by dividing total catch by the total number of days, for example) will reflect variations in the distribution of fishing effort among months, regions and gears more than it does an actual trend in the availability of fish to the gear. One common way of handling this problem is to model the catch per day by use of the general linear model (GLM)

(1) $$\ln(\mathbf{c}) = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}$$

where **c** denotes the vector of catch per day values, $\boldsymbol{\beta}$ is the vector of categorical factors representing year, gear, month, region and the associated first order interactions, **X** is the corresponding design matrix, and $\boldsymbol{\varepsilon}$ is a vector of random errors. The standardized value of annual catch per trip is

(2) $$c_Y = \exp\{\square + \square_Y + (d+1)(s_R^2 - s_Y^2)/2d\}$$

where $\square_Y$ is the main effect for year y, s_R^2 is the residual variance, d denotes the degrees of freedom for the residual variance and s_Y^2 is the estimated variance of $\square + \square_Y$ (Bradu and Mundlak 1970, Gavaris 1980). The SAS code to conduct these models has been made available to the CRFM.

An approach was used to develop the linear models of the trawls and gillnet catch rates. Factors were included in the model if they were statistically significant and explained at least a few percent of the variation in the data. First order interaction effects were included using the same criteria. Higher order interactions were not estimated owing to insufficient data. Interactions involving years were treated as random effects, which allows the model to more accurately reflect the uncertainty in the parameter estimates while still permitting the construction of an annual index (essentially, application of the random effects approach assumes that any changes in the importance of a given month or region across years are effectively random over the time scale considered, with a constant log-scale variance, and can therefore be integrated out of the likelihood expression).

1.8.6.3 Results and Discussion

The final linear model for the trawl fishery included the main effects and interaction for region and month. The final model for the gillnet fishery included all main effects and first order interactions for gear, region and month. Interactions between year and month and between year and region were treated as random effects. An inspection of the distribution of the residuals and the associated QQ plots suggests the assumptions of normality and constant variance are satisfied for both models.

The standardized trawl and gillnet catch per day series are shown in Figure 1. The results suggest that the availability of younger fish (probably less than 5 years old) to the trawls has remained fairly constant since 1998 except for a spike in 2005. This spike was based on few samples, and is not significantly different from the values in some of the earlier years (as indicated by the very large confidence intervals). On the other hand, the availability of larger fish (probably age 5 and older) to gillnets appears to have decreased after 1999. On this basis, it appears that growth overfishing is occurring (meaning too many seatrout are caught before they have had a chance to grow to an optimal size), but not necessarily recruitment overfishing (there is no evidence that the abundance of young animals has declined despite the declining availability of larger fish).

1.8.6.4 Management

The estimates of Z from the length-converted catch curves and mean-length analyses average between 0.98 (growth parameters from previous assessments) and 1.4 yr^{-1} (growth parameters from Charlier *et al*. (2000)). Yield per recruit analyses suggest that the fishing mortality rate that maximizes the yield per recruit is between 0.55 (growth parameters from previous assessments) and 0.65 (growth parameters from Charlier *et al*.). Given the corresponding assumed levels of M, this suggests that growth overfishing may be occurring. It is important to keep in mind that the estimates of Z implicitly include a possible increase in the ability of fish to avoid the gear with size and also the tendency of older fish to move offshore. Hence, the Z values obtained pertain mostly to younger animals (less than age 5) and may overestimate mortality because they also reflect losses due to evasion and migration. The mortality rate on larger animals could not be ascertained through the same methods because of the unknown selection characteristics of the gillnet. The high fishing mortality rates suggested above are consistent with the trends shown by the standardized indices, which indicate the availability of larger fish (probably age 5 and older) to gillnets has decreased after 1999. It appears that growth overfishing is occurring, i.e., too many seatrout are caught before they have had a chance to grow to an optimal size. It is recommended that trawling be substantially reduced if maintaining higher yields of seatrout is a priority of managers.

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2.0 Guyana Bangamary (*Macrodon ancylodon*) Fishery

2.1 Management Objectives

The Draft Fisheries Management Plan of Guyana states that the objectives for bangamary management are:

- To maintain the stock at all times above 50% of its mean unexploited level.
- To maintain and improve the net income per fisher at a level above the national minimum desired income.
- To include as many of the existing participants in the fishery as is possible given the biological, ecological and economic objectives listed above.

2.2 Status of Stocks

The recent reductions in the standardized abundance indices for gillnet in 2004 and Chinese seine in 2006 are cause for concern. However, it is unclear whether these trends continue. The data were insufficient to clearly determine the status of the stock but the recent decline in gillnet catches is cause for concern.

2.3 Management Advice

It is recommended that reductions in trawling be considered to maintain higher yields of bangamary**.** There were data gaps and other uncertainties that influenced the ability of the assessment to give good results. In view of this, more specific management advice cannot be given at this time. Data collection needs to be improved and, pending this, the precautionary approach needs to be adopted.

2.4 Statistics and Research Recommendations

2.4.1 Data Quality

- Catch and effort data quality needs to be improved. The on-going collection of catch, effort, and size frequency data should be expanded to cover all months, gear types and areas where fishing is occurring (this information is necessary to develop total catch and CPUE series).
- This assessment used catch and effort data from 1995 to present however catch and effort data were collected prior to 1995. These data records from the earlier surveys need to be reviewed and computerized, so that longer time series may be examined which will result in more informative assessments.

2.4.2 Research

- Ototliths (ear bones) and scales should be collected from a sample of fish for a feasibility study on determining age. Assuming that this is successful, it will be possible to better characterize what ages are being exploited and to develop a more suitable growth curve.

- The observer programme for the trawl fleet needs to be reinstated to obtain information on fishing operations and total catches, including discards of commercial species, onboard vessels.

- Collaborate with countries such as Suriname, Venezuela and Brazil for stock assessments since bangamary is considered a shared stock.

2.5 Stock Assessment Summary

The analysis utilized recent (1996-2006) length and catch per unit effort (CPUE) levels for artisanal gillnet, Chinese seine and trawl fleets operating in Guyana. Catch per day was standardized to account for unbalanced and incomplete sampling across months, regions and years by use of the general linear model (GLM). The standardized trawl Chinese seine and gillnet catch per day series are shown in Figure 1.

The results suggest that the availability of younger fish to Chinese seines and slightly older fish to the trawls has fluctuated with little trend since 1996. In both gears the highest catch per day on record occurred in 2005, but these estimates were based on few samples and are not significantly different from the values in some of the earlier years. A similar trend was noticed for seatrout, suggesting the upswing may be related to mutually favourable environmental conditions. The availability of larger fish to gillnets appears to have also fluctuated over the time series; however a substantial decrease was estimated for 2004.

Data for later years are needed to confirm whether the results represent a trend or simply an anomalous year. There may be some concern that growth overfishing is occurring (too many bangamary are caught before they have had a chance to grow to an optimal size), but not necessarily recruitment overfishing (there is no evidence that the abundance of young animals has declined despite the 2004 reduction in the availability of larger fish). It was noted, that the time series does not extend back to the inception of the fishery and therefore it is impossible to tell whether recruitment has been reduced relative to unfished levels.

2.6 Special Comments

Alternative data sources for monitoring the gillnet fishery need to be developed. Either samples need to be aged using hard parts, such as scales or otoliths, or catch and effort monitoring needs to be conducted.

Trawl length frequency data provide useful information on the stock. Length frequency sampling from the trawl fishery should be increased.

2.7 Policy Summary

To manage, regulate and promote the sustainable development of Guyana's fishery resources for the benefit of the stakeholders in the sector and the nation as a whole.

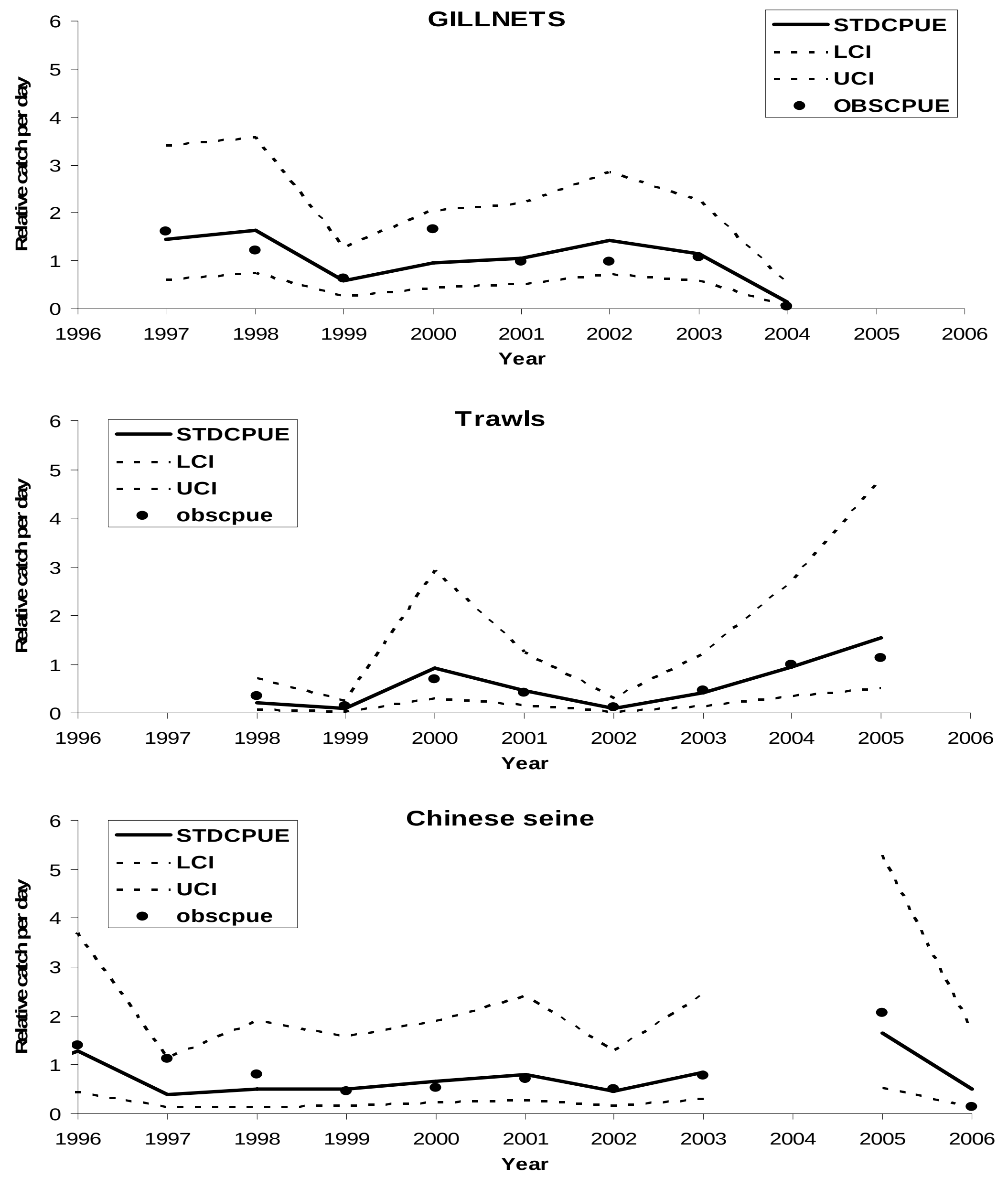

Figure 1: Standardized catch per day for gillnets (top), trawls (middle) and chinese seine. The three series were normalized to have the same scale by dividing the annual values for each series by the average for that series. STD CPUE = standardized catch per unit effort; dashed lines indicate 95% confidence intervals; obscpue = observed catch per unit effort.

2.8 Scientific Assessments

2.8.1. Assessment 1

2.8.1.1 Description of the fisheries

The Inshore Artisanal Fishery consists of vessels ranging in size from 6 to 15 meters propelled by sails, outboard or inboard engines and using gear that include pin seines, chinese seines (a fyke net), cadell lines, drift seines and circle seines (modified gillnets). The larger vessels have ice boxes and go on fishing trips that last as long as 12 or more days. Smaller vessels may or may not have ice boxes and their operations are either tidal or diurnal. Except for the large drift seine vessel, which may or may not be decked, most vessels are flat bottomed dory type with little draft which affords great maneuverability over shallow muddy and sandy bottoms.

Pin seines or beach seines are 2 m high and up to 2,000 m in length with a stretched mesh size of 9 cm or less. The net is set at high tide in the inter-tidal zone. During the ebbing tide fish are trapped and then retrieved from the mud flats. The catch includes mullet/queriman (*Mugil sp*.), snook (*Centropomous sp*), bangamary (*Macrodon ancylodon*), croaker (*Micropogonias furnieri*) and catfishes of the family *Ariidae*. About 83 vessels are involved in pin seine fishing.

Chinese seines are funnel-shaped nets 16 m long and 4-6 m wide at the mouth end. Their mesh size gradually tapers from the mouth end (8 cm) toward the bag end (1 cm). The net is attached to poles and set on mud banks along the coast, in rivers and particularly at river mouths. Fish and shrimp are swept into the bag of the net by the tidal currents. Each boat operates between one and ten nets. The catch is normally made up of seabob (*Xiphopenaeus kroyeri*), whitebelly shrimp (*Nematopalaemon schmitti*), bangamary (*Macrodon ancylodon*), butterfish (*Nebris microps*) and catfishes, mainly of the family *Ariidae*. An undetermined amount of immature fish is caught and in most cases discarded. The mortality of these fish is 100%. Over 400 vessels are involved in Chinese seine fishing.

Gillnets (polyethylene) vary in length from 1,000 to 1,600 m and are 4 m deep with a stretched mesh measure of 20 cm. Nets are set and hauled manually from the boats. The catch consists mainly of gray snapper (*Cynoscion acoupa*), sea trout (*Cynoscion virescens*), bashaw (*Cynoscion jamaicensis*), pagee (*Lobotes surinamensis*), tarpon (*Tarpon atlanticus*), gillbacker (*Arius grandicassis*), mackerel (*Scomberomorus maculates*) and sharks (*Carcharhinus spp*.) (Chakalall and Dragovich 1979). Some 400 vessels are involved in gillnet fishing.

Modified versions of the gillnet approximately 300 m in length, made of nylon, and with smaller mesh sizes (15 cm), are being used by some operators in the near shore areas to catch mainly catfishes (*Arius spp*.) but younger stages of grey snapper (*Cynoscion acoupa*) and sea trout (*Cynoscion virescens)* also occur in the catch. Immature fish are discarded. About 200 vessels are involved in gillnet (nylon) fishing.

Another version of the gillnet made of nylon and called a circle seine is used in the Corentyne River in Berbice. The average length is 300 m with small stretched mesh sizes. The catch consists of laulau (*Arius spp*), silver bashaw (*Plagioscion spp)*, and highwater (*Hypophthalmus edentatus*). Approximately 8 vessels are involved in circle seine fishing.

Activity in the Inshore Artisanal Fishery occurs along the Coastline. Guyana has ten administrative regions (Figure 2). The effects of the trawl fishery on the demersal fin fish stocks in regard to by-catch resulting from shrimping (prawns and seabob) and fin fish as a result of direct fishing would have to be taken into consideration when looking at expansion. In like manner the effects of trawling for seabob would have some bearing on seabob and whitebelly shrimp available to the chinese seine operators and vice versa.

The data collection programme is a stratified random programme. Stratification is done by vessel/gear type. The landings, employment and value of the catch were important factors that led to this type of stratification. This determined the number of vessels to be sampled per month per gear type.

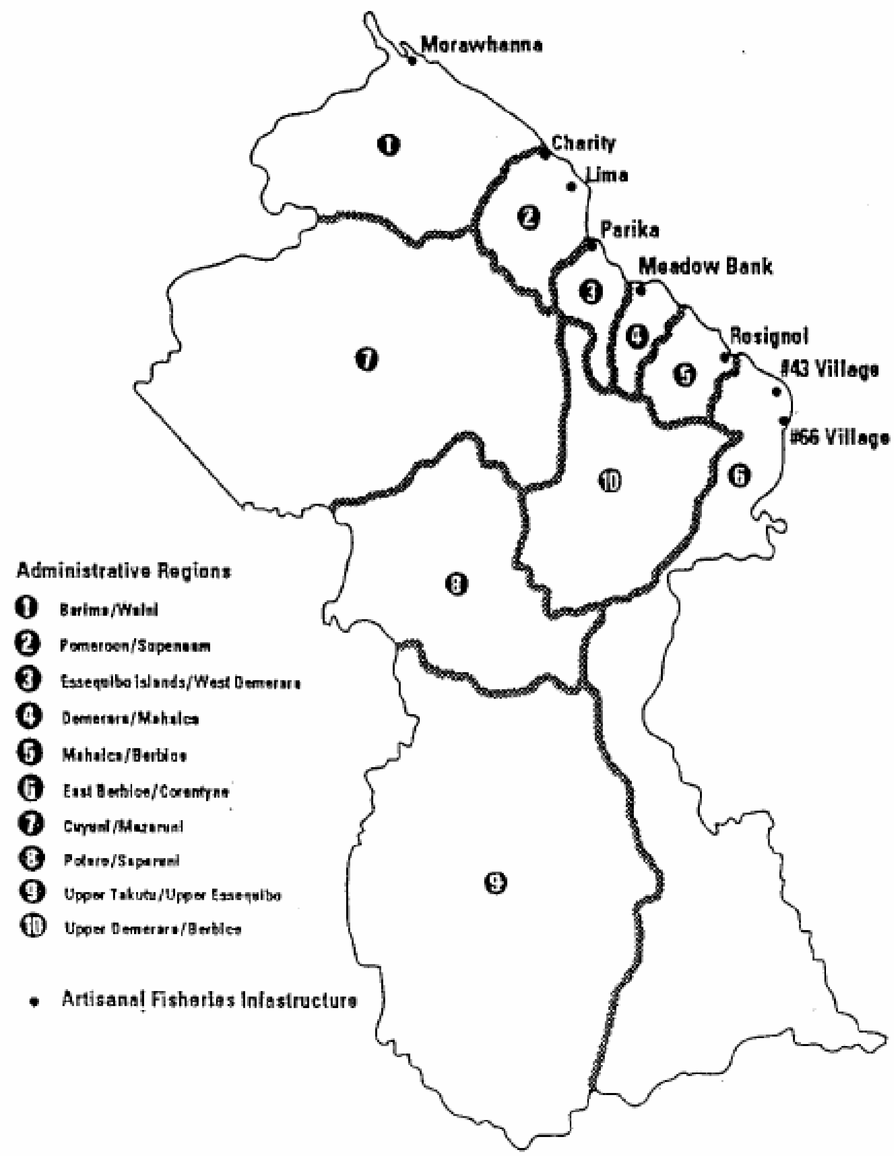

Figure 2: Map showing the ten administrative regions in Guyana

At the beginning of every month, sampling schedules are prepared in the three Regions for data collection. A total of 82 vessels are chosen to be sampled for data. These vessels are randomly selected from landing sites in the Regions. They comprise 20 chinese seine, 17 gillnet nylon, 4 cadell, 15 gillnet (outboard), 6 gillnet (inboard), 4 pin seine, 3 handlines and 2 traps for the artisanal fishery and 6 seabob and 5 prawns for the industrial fishery.

The vessels sampled in Region 4 are all the industrial vessels and forty-two artisanal. In Regions, six and two the number of vessels sampled is 13 and 14 respectively.

The number of vessels being targeted for data collection has been reduced due to a manpower shortage. Only 65 vessels are being sampled per month. Sampling is done three days per week Tuesday to Thursday and at least two trips are scheduled per day. The number of vessels targeted per trip would depend on the landing site being targeted, the number of data collectors and the number of vessels at the site.

Catch and effort and biological data are collected from the vessels selected randomly at the landing sites.

2.8.1.2 Overall Assessment Objectives

The main objective was to analyze the available data on the Artisanal Fishery and to build a stock assessment approach able to give management advice for this fishery. Data exist to estimate the catch and fishing effort by each gear. In addition a biological sampling programme was conducted during the period of 1996-2006 to collect length frequency data on the species. The objective was to develop a standardized Catch per Unit Effort (CPUE) index.

2.8.1.3 Data Used

Ten years of data collected by the Fisheries Department were used for the period of 1996-2006. (Described below).

Name	**Description**
Catch sampling	Landings were sampled from both artisanal vessels and industrial vessels from 1996-2006 based on a sampling program.
Trip interview programme	Trip catch and effort sampling for 1996 – 2006 provides total catch and effort.

2.8.1.4 Objective

The objective was to develop a standardized Catch per Unit Effort (CPUE) index.

2. 8.1.5 Method/Models

Information on bangamary catch per trip (pounds), trip duration (days) and the size of the bangamary that were caught was available for several gear types. Records on the total number of trips also exist, but have yet to be entered into an electronic database and were not available for this meeting. Moreover, for some gears the catch per trip data covered only a few months in a few years. Hence, it was not possible to develop a time series of total landings. On the other hand, the available samples were sufficient to examine annual trends in size and catch per day for several of the gears.

The most complete catch data came from the Chinese seine, trawl and nylon gillnet fisheries between 1996 and 2006. Regions 1 and 2 were sparsely sampled and believed to be very similar to those operating off region 3, therefore the three regions were combined (see Figure 2 for a description of the regions). Separate indices were developed for gillnets, trawls and Chinese seine because the size frequency distributions for these gears are very different (see Figure 1). The magnitude of the catch and number of samples varied by month and region of the coast. Hence, it may happen that a simple nominal catch per day index (created by dividing total catch by the total number of days, for example) will reflect variations in the distribution of fishing effort among months and regions more than it does an actual trend in the availability of fish to the gear. One common way of handling this problem is to model the catch per day by use of the general linear model (GLM)

(1) $\ln(\mathbf{c}) = \mathbf{X\beta} + \boldsymbol{\varepsilon}$

where **c** denotes the vector of catch per day values, β is the vector of categorical factors representing year, gear, month, region and the associated first order interactions, **X** is the corresponding design matrix, and ε is a vector of random errors. The standardized value of annual catch per trip is

(2) $c_Y = \exp\{\mu + \beta_Y + (d+1)(s_R^2 - s_Y^2)/2d\}$

where β_Y is the main effect for year y, s_R^2 is the residual variance, d denotes the degrees of freedom for the residual variance and s_Y^2 is the estimated variance of $\mu + \beta_Y$ (Bradu and Mundlak 1970, Gavaris 1980). The SAS code to conduct these models has been made available to the CRFM.

A stepwise approach was used to develop the final linear models. Factors were included in the model if they were statistically significant and explained at least a few percent of the variation in the data. First order interaction effects were included using the same criteria. Higher order interactions were not estimated owing to insufficient data. Interactions involving years were treated as random effects, which allows the model to more accurately reflect the uncertainty in the parameter estimates while still permitting the construction of an annual index (essentially, application of the random effects approach assumes that any changes in the importance of a given month or region across years are effectively random over the time scale considered, with a constant log-scale variance, and can therefore be integrated out of the likelihood expression).

2.8.1.6 Results and Discussions

The final linear models for all three fisheries included the main effects and interaction for region and month. Interactions between year and month and between year and region were significant and treated as random effects. An inspection of the distribution of the residuals and the associated QQ plots suggests the assumptions of normality and constant variance were not too seriously violated. However, it might be advantageous to combine months into quarters or perhaps some more biologically meaningful seasons to reduce the degrees of freedom (not all months are represented in all regions and years).

The standardized catch per day series is shown in Figure 1. The results suggest that the availability of younger fish to Chinese seines and slightly older fish to the trawls has fluctuated with little trend since 1996. In both cases the highest values on record occurred in 2005, but these estimates are based on rather few samples and are not significantly different from the values in some of the earlier years (as indicated by the very large confidence intervals). A similar trend was noticed for seatrout, suggesting the upswing may be related to mutually favourable environmental conditions. The availability of larger fish to gillnets appears to have also fluctuated over the time series; however a substantial decrease was estimated for 2004. Data for later years is needed to confirm whether this represents a trend or simply an anomalous year. On this basis, there may be some concern that growth overfishing is occurring (meaning too many bangamary are caught before they have had a chance to grow to an optimal size), but not necessarily recruitment overfishing (there is no evidence that the abundance of young animals has declined despite the 2004 drop in the availability of larger fish). It should be kept in mind, however, that the time series does not extend back to the inception of the fishery; therefore it is impossible to tell whether recruitment has been reduced relative to unfished levels.

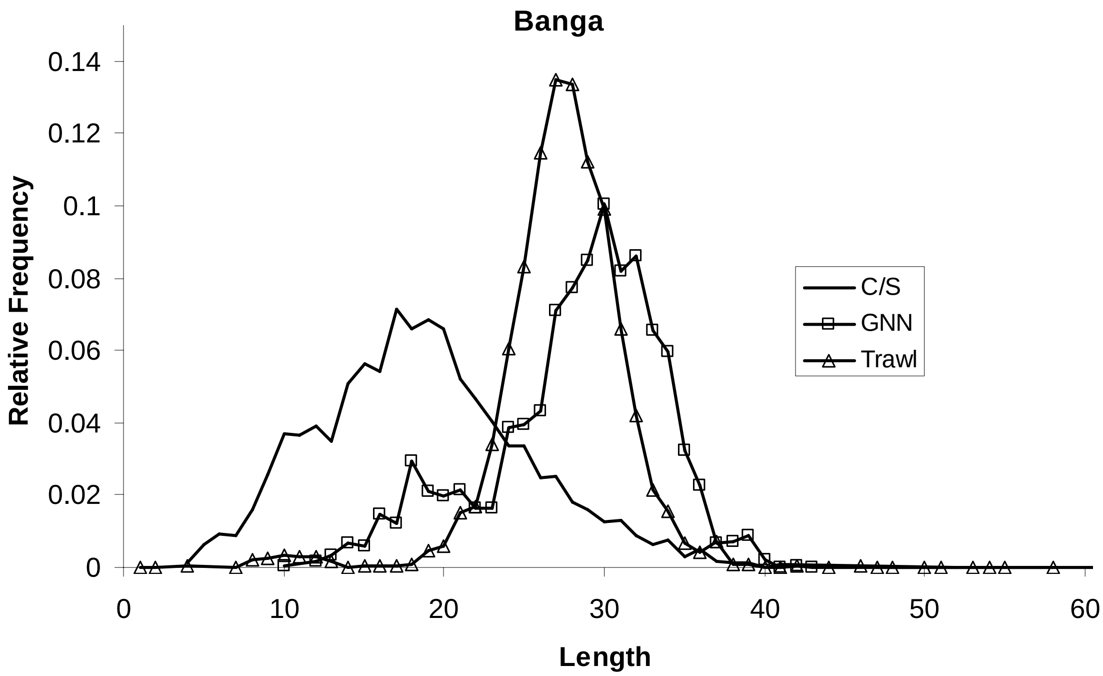

Figure 3: Size-frequency distribution of catch from the trawl and gillnet fisheries of Guyana (GNN=gillnet nylon, C/S Chinese seine and trawl)

<u>2.8.1.7 Management</u>
The recent drops in the standardized indices for gillnet in 2004 and Chinese seine in 2006 are cause for concern, however it is unclear whether these trends have continued since. It is recommended that managers consider reductions in trawling if maintaining higher yields of bangamary is a priority.

2.9 References

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Chakalall, B. and Dragovich, A. (1979). Artisanal Fishery of Guyana. 13 p. Cited in: Shepherd, D., A. Hackett, and R. Charles. 19xx. *FAO Fishery Report* No. **600**.

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3.0 Guyana Seabob (*Xiphopenaeus kroyeri*) Fishery

3.1 Management Objectives

The Draft Fisheries Management Plan of Guyana states that the objectives for seabob management are:

1. To maintain the seabob stock at all times above 50% of its mean unexploited level.
2. To maintain all non-target species, associated and dependent species above 50% of their mean biomass levels in the absence of fishing activities.
3. To stabilise the net incomes of the operators in the fishery at a level above the national minimum desired income.
4. To include as many of the existing participants in the fishery as is possible given the biological, ecological, and economic objectives.

3.2 Status of Stocks

The current data are not sufficient to fully determine the status of the stock. However, there is continuing concern that the seabob fishery is fully- to over- exploited. In last year's assessment, it was noted that the mean size of animals has decreased over the years suggesting increasing fishing mortality (Figure 1).

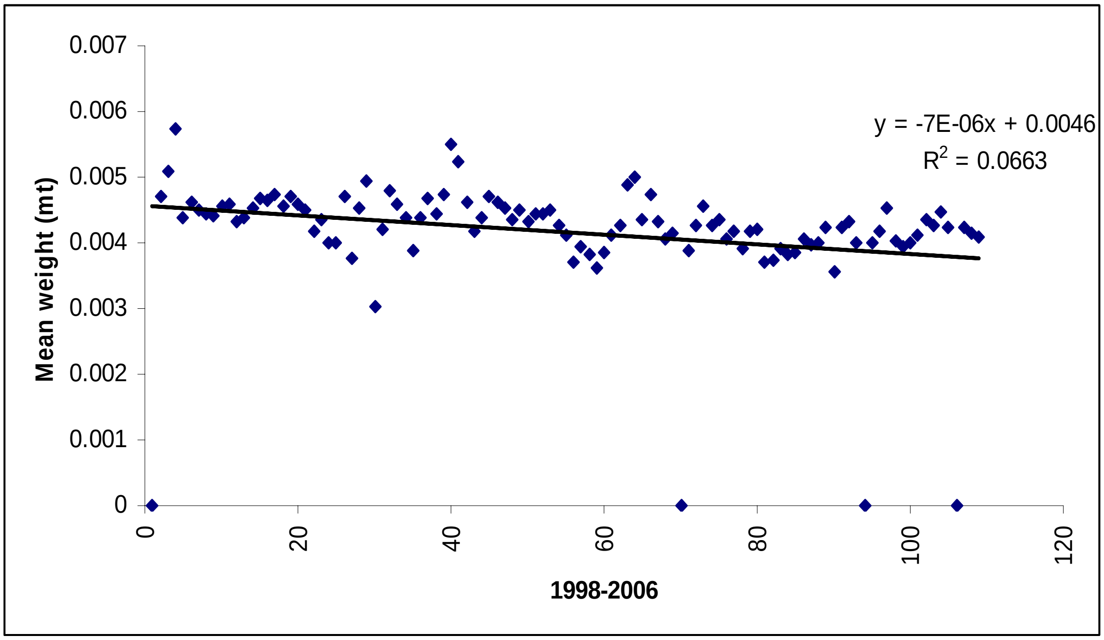


Figure 1: Plot of mean weight of the shrimp landed in each month versus month, from 1998 to 2006. A declining trend over years in mean weight is consistent with increasing fishing mortality leading to fewer shrimp reaching large size. Data for 2006 appear rather flat but at a low mean body size.

3.3 Management Advice

Studies need to be conducted to determine the effectiveness of the current closed season from September – October which has been decided on by members of the trawler association since 2003. This current study indicates that the current closed season occurs at the least effective time for reducing fishing mortality and for protecting recruitment. It is recommended that the closed season be placed in May to protect the pulse of recruitment until it reaches the next market category in June.

3.4 Statistics and Research Recommendations

3.4.1 Data Quality

1. Data on length frequencies need to be collected to be able to determine seasonal changes in size, sex and maturity compositions, and to determine growth rates. The landings by market category are too broad to enable determination of growth, recruitment patterns and appropriate placement of the closed season.

2. Data need to be recorded in a standardized form to ensure that it is easily interpreted and of sound quality. There is a need to revise the format of the data sheets used for recording catch and effort data. A standard spreadsheet or database for computerizing catch and effort and length data needs to be developed.

3. The landings and effort data from the processing plant need to be computerized for inclusion into future analyses. The effort data are not well documented and/or sparse, which makes evaluating impacts of the closed seasons difficult.

3.4.2 Research

1. The observer program should be reinstated in order to monitor catch onboard vessels to get catch rate information, length-frequency data, and geographic information.

2. Economic data such as price per pound for the various market categories should be documented over the course of a year.

3. Analyses of length frequencies to determine growth, catch rates to determine abundance, and landings data need to be refined once the additional data specified in section 1.4.1 have been obtained. This will lead to improved understanding of the role of closed seasons in fisheries management.

3.4.3 Management

Further scientific studies on the seabob fishery need to be conducted to determine the most appropriate period in which to implement a closed season. The results of these studies will be incorporated into national regulations and should be included in the granting of licenses.

3.5 Stock Assessment Summary

Because a closed season was enacted beginning with 2002, only the data from January 1998 to December 2001 was used in this analysis to prevent a bias from the effects of the closed season. Trends in recruitment were looked for by analyzing the CPUE by numbers of shrimp for the commercial classes for each month averaged over the time span. The CPUE was then used to create an average $US per unit of effort (1 unit of effort = 1 boat-day) for all the months. The total landings and market values for the commercial classes were used to establish the monetary value of the fishery each month.

The value of the landings peaks in June (Figure 2). September has the lowest value of the landings and October is the fourth lowest month. The maximum value of the catch per vessel per day peaks in April (Figure 3) and the lowest CPUE occurs in October with September having the third lowest value.

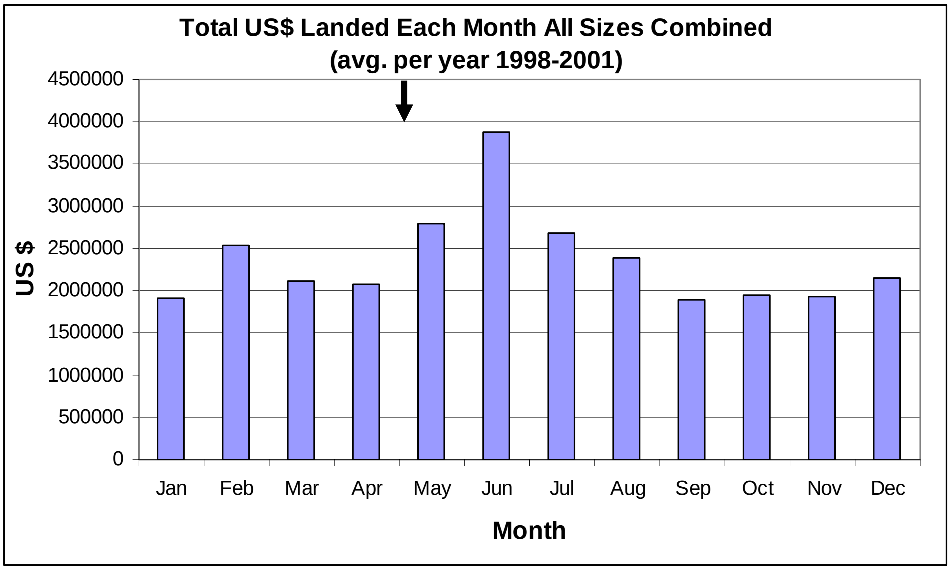


Figure 2: The total US$ landed each month (all sizes combined). The data from January 1998 to December 2001 were combined and averaged. The arrow over the month of June indicates this month has the highest sales value.

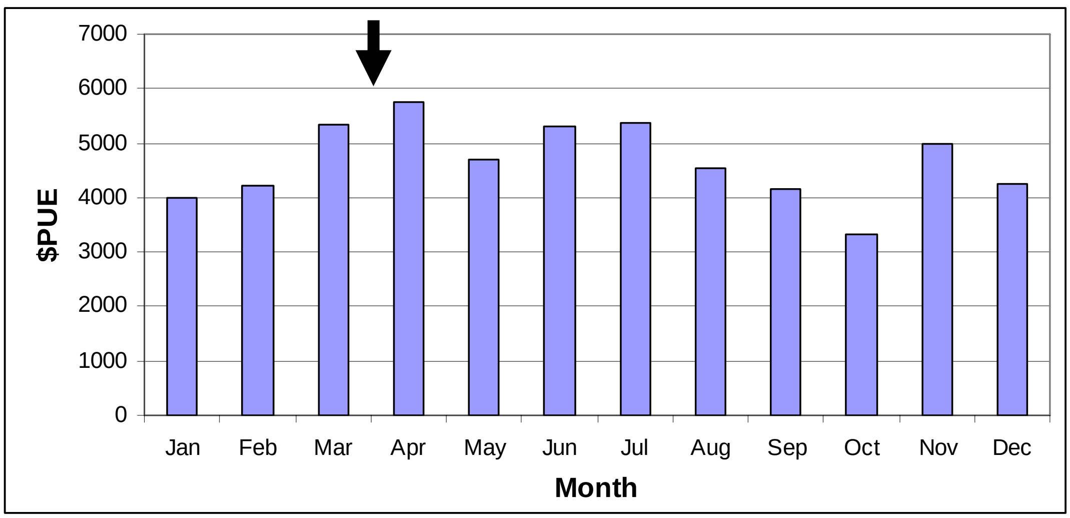


Figure 3: Average US$ per boat day earned each month in the years 1998 to 2001.

The CPUE for the commercial landings shows a peak of recruitment in the smallest size category (300/500 tails/lb) in May (Figure 4). This recruitment can be followed into the next market category (200-300 tails/lb) in June (Figure 5).

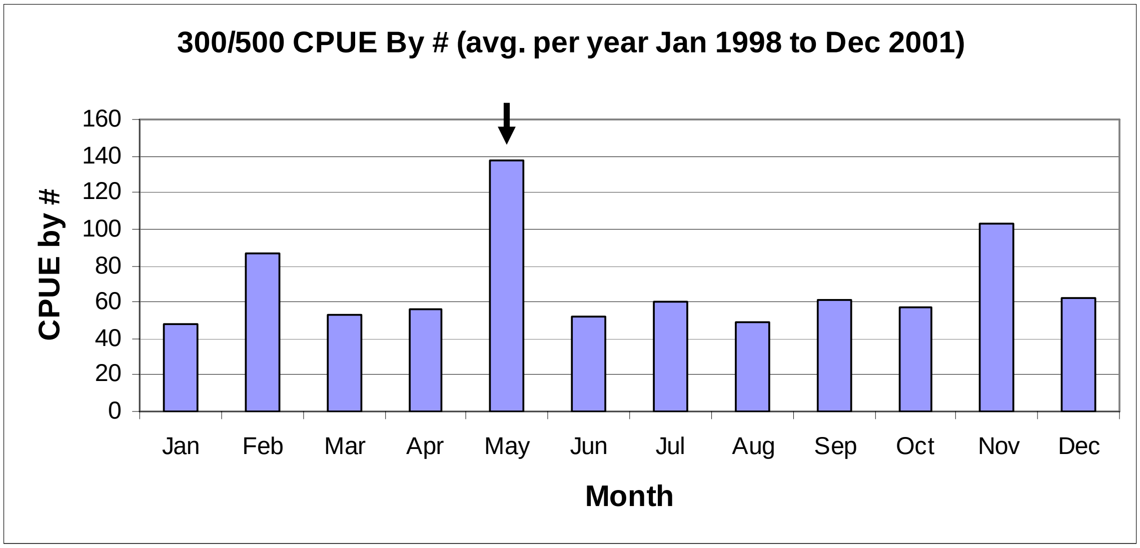


Figure 4: Trends in CPUE by number for commercial size 300-500 tails/lb by month of the year.

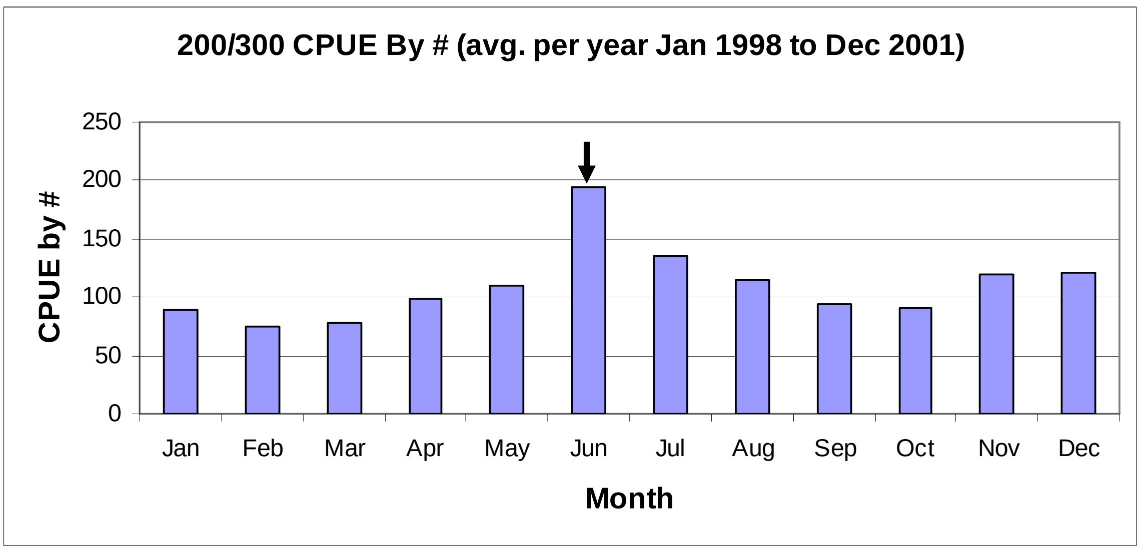


Figure 5: Trends in CPUE by number for commercial size 200-300 tails/lb by month of the year.

Thus, it appears that a seasonal closure in September-October is the least effective way to reduce fishing mortality and does little to protect against recruitment overfishing because recruitment is low during the closure. In contrast, a closure in May would protect a large pulse of recruitment and allow it to reach the next highest market category with a higher price per pound in June.

3.6 Special Comments

Data on length frequency and growth parameters need to be collected to ascertain which month is best for the closed season. From the current data, May is the suggested month. This would protect the pulse of smaller recruits for the next month

3.7 Policy Summary

To manage, regulate and promote the sustainable utilization of Guyana's fishery resources for the benefit and safety of all stakeholders in the sector and the nation as a whole.

3.8 Scientific Assessments

3.8.1 Background or description of the Fishery

The offshore industrial shrimp trawl fleet exploits mainly penaeids (*Penaeus* spp.) and seabob (*Xiphopenaeus kroyeri*). Seabob are also caught by the Chinese seine operators in the inshore artisanal fishery.

At present, there are 100 trawlers registered and licensed to catch seabob. The seabob is processed at six plants located along the East Bank of the Demerara River. There are about 373 Chinese seine vessels catching seabob and white belly shrimp (*Nematopalaemon schmitti*).

The management unit is considered to be one or more stocks located over the continental shelf of Guyana. It is possible that these stocks are shared with Suriname. For the purpose of this assessment, the Guyana fishery is treated as a single management unit.

3.8.2 Overall Assessment Objectives

Using the current landing and effort data, look for patterns in recruitment, estimate the growth parameters or create growth curves, and evaluate options for improving yields through the use of a closed season.

3.8.3. Data Used

Landings by month by market category by year

Name	Description
landings	Weight landed by commercial size category was collected from all six seabob processing companies. The data covered the period January 1998 to December 2001.
Catch and effort data	Data on weight landed by market category for individual trips with the corresponding effort in days fished

Data from 1998 to 2001, representing the period prior to the implementation of seasonal closures, were combined for analysis.

3.8.4. Assessment

<u>3.8.4.1. Objective</u>

To analyze the CPUE by numbers of shrimp for the commercial classes for each month averaged over the time span in order to determine when recruitment occurs during the year and to infer growth rates if possible. This information will be used to evaluate options for setting the closed season in various months.

<u>3.8.4.2. Method/Data</u>

Because a closed season was enacted beginning with 2002, the data from January 1998 to December 2001 was used in this analysis to prevent a bias from the effects of the closed season.

Landings in tons for each market category were converted to landings in number by converting to weight in pounds and multiplying by the average number of tails per pound, taken to be the midpoint of the market category (i.e., it was assumed that the 300 – 500 tails/lb market category contained on average 400 tails/lb).

Average body weight in a month was obtained by summing across market categories the landings in weight and dividing by the sum of numbers landed.

The value of the landings in a month was obtained by multiplying the landings in pounds by the price per pound and summing across market categories. The prices used were: US$ 2.75, 2.55, 2.10, 1.90, 1.50, 0.90 for market categories 70-90, 90-110, 110-150, 150-200, 200-300, 300-500, respectively.

Average sale value of the catch per boat-day was obtained by multiplying the catch per unit effort in weight by the price per pound and summing across market categories for each month.

The catch per unit effort was calculated by number for each market size category in each month.

3.8.4.3. Results

In last year's assessment, it was noted that the mean body size has been declining over time. This analysis was updated (Figure 1) and it appears that the mean body size in 2006 was similar to that of 2005 (the residuals are all positive indicating that the data do not support a further decline in mean size). However, the mean size is currently at the lowest level observed.

The value of the landings shows a prominent peak in June (Figure 2). September has the lowest value of the landings and October is the fourth lowest month. The maximum value of the catch per vessel per day ($PUE) peaks in April (Figure 3) and the lowest $PUE occurs in October with September having the third lowest value.

The CPUE for the commercial landings shows a peak of recruitment in the smallest size category (300/500 tails/lb) in May (Figure 4). This recruitment can be followed into the next market category (200-300 tails/lb) in June (Figure 5).

For completeness, we also show the monthly trend in CPUE by number for the 150/200, 110/150, 90/110, and 70/90 size classes in figures 6, 7, 8 and 9, respectively.

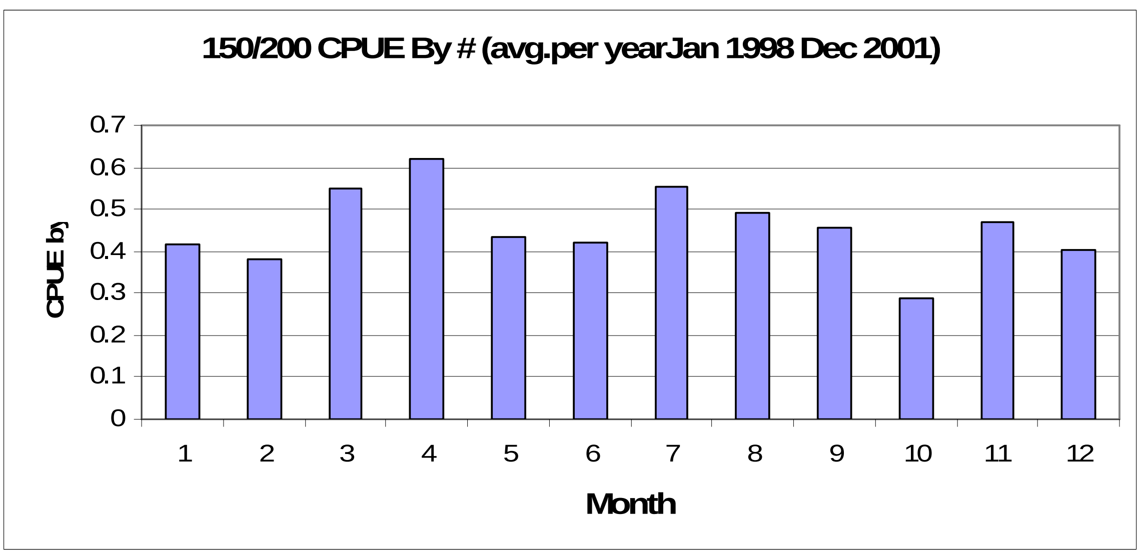


Figure 6: Trends in CPUE by number for commercial size 150/200 tails/lb by month of the year. The 150/200 size shrimp peaks in April.

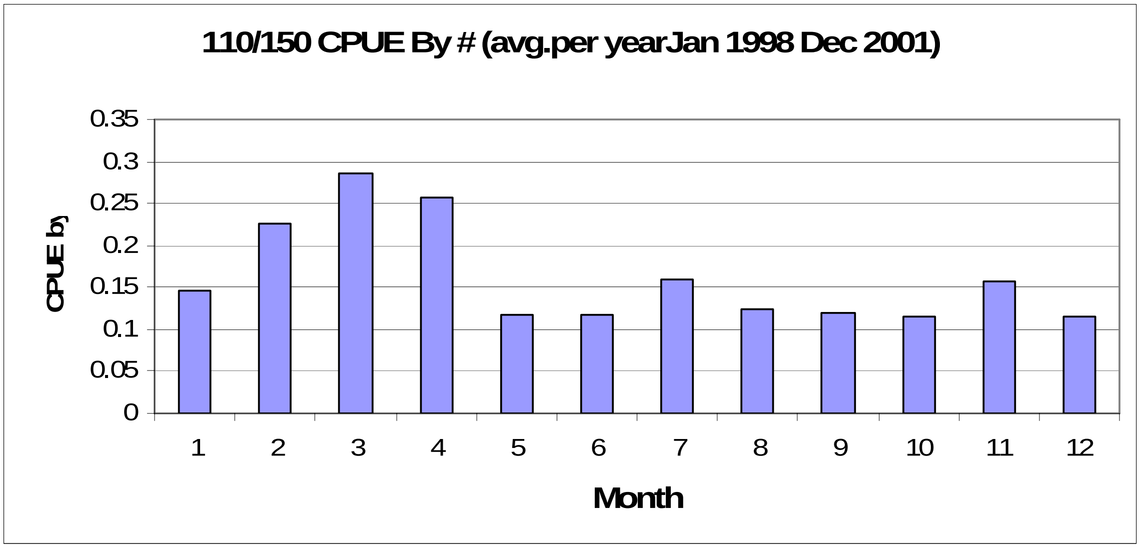


Figure 7: Trends in CPUE by number for commercial size 110/150 tails/lb by month of the year.

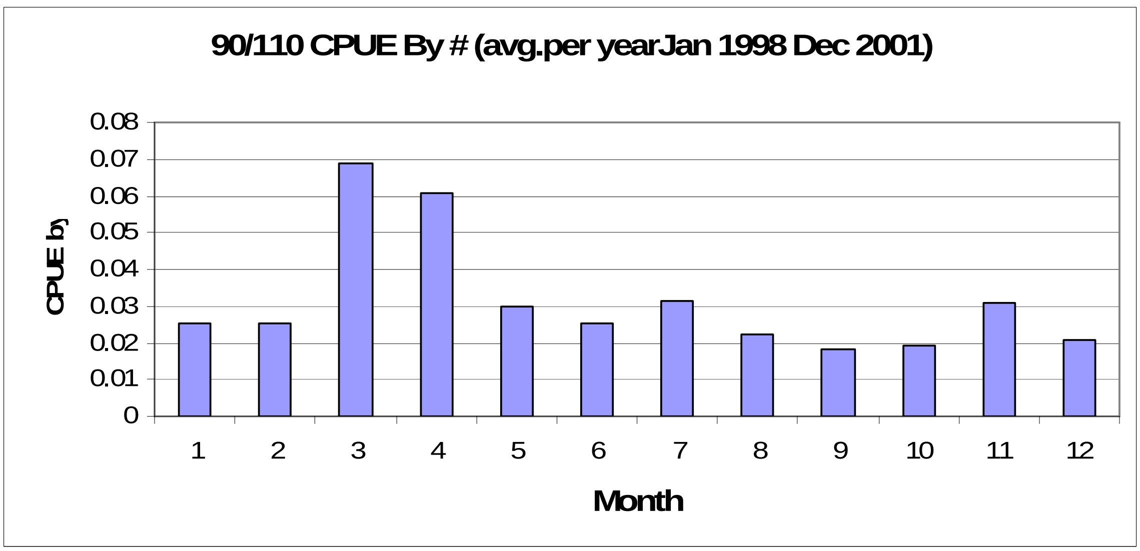


Figure 8: Trends in CPUE by number for commercial size 90/110tails/lb by month of the year.

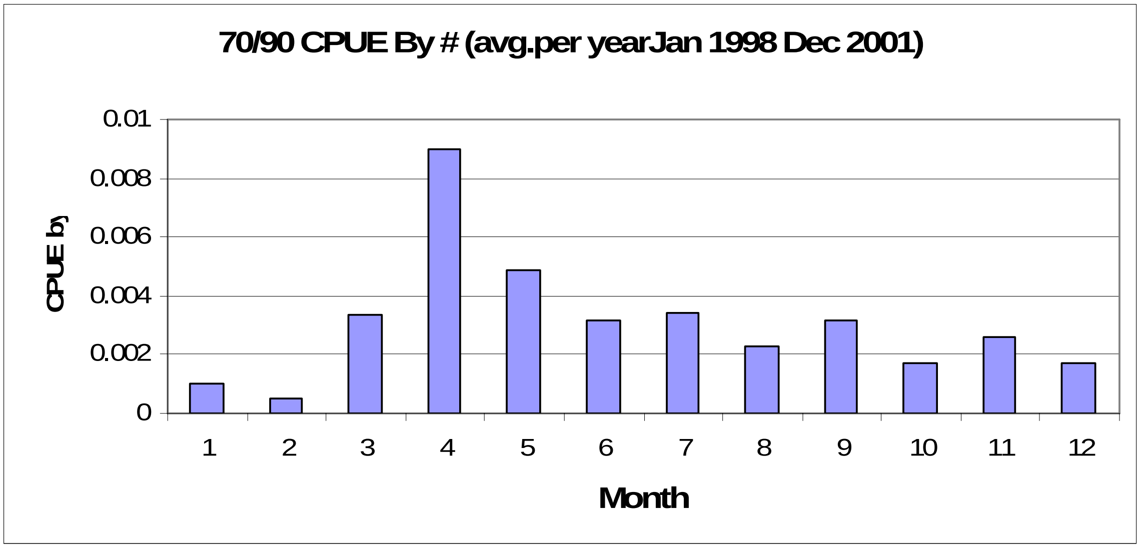


Figure 9: Trends in CPUE by number for commercial size 70/90 tails/lb by month of the year.

3.8.4.4. Discussion

Recruitment in September-October appears to be low, as does the quantity landed. Closing the fishery in September-October does not appear to protect recruitment. Nor does a closure in this period reduce fishing mortality as much as closure in the other months would.

There is a clear peak in recruitment in May seen in the 300-500 market category (Figure 4). This pulse of recruitment can be followed to the next market category (200-300) in June (Figure 5). Thus, closure in these months would protect recruitment. The decision on when to close the fishery should also consider the value of the landings and the sale value of the catch per boat-day. The value of the landings peaks in June (Figure 2) and the sales value per boat-day peaks in April (Figure 3). Thus, it would appear that a closure in May would protect a large pulse of recruitment which would then be available in the next larger market category, with a higher price per pound, in June.

3.8.5 Management

Given the concern about the level of exploitation of the seabob fishery and the willingness of the industry to accept a closed season, the task is to find the time of year when a closure will have the greatest economic benefit and conserve the stock the best. The results presented here suggest that a closure in May will protect recruitment and result in larger shrimp of greater value per pound.

4.0 The Shrimp (*Farfantepenaeus subtilis* and *Farfantepenaeus brasiliensis*) Fishery of Suriname

4.1 Management Objectives

- Long term conservation of the resources.
- Maximisation of the long-term production of shrimp by achieving MSY (Maximum Sustainable Yield)
- Contribution to the trade balance; generation of foreign currency; maximisation of exports. These objectives may coincide with MSY or MEY.

4.2 Status of the Stock

In the previous assessment of these stocks by WECAFC (FAO, 2001), it was concluded that the shrimp stocks are fully exploited and the fishing mortality was high and rising. It was estimated that the fishing mortality was several times higher than F_{MSY}. Licensing data show that the fishing effort (number of vessels) has declined by 40% (Figure 1). Because of the high fishing mortality, the possibility of implementing a closed season to improve the yield was considered in this current assessment.

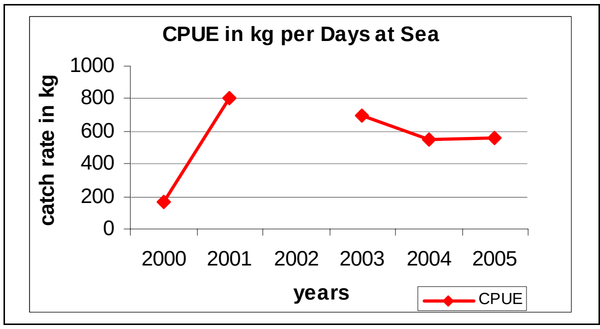


Figure 1a: Catch rate values for both penaeid species. Cpue is declining from 2001.

Figure 1b: Effort in days at sea, showing a decline since 2000 but not since 2001.

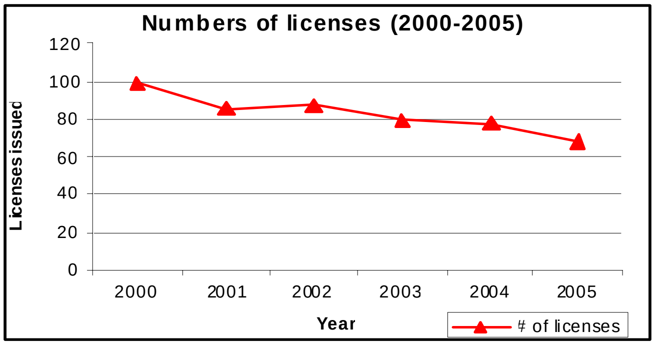


Figure 1c: The effort expressed in the number of licenses issued each year is showing a gradual decline.

4.3 Management advice

It is recommended that management measures should be taken to rebuild the stock and improve yields. One option is to initiate a closed season. There is a clear peak in recruitment of *Farfantepenaeus subtilis* in July-August and a broader peak for *Farfantepenaeus brasiliensis* around November (Figure 2). However, because recruitment of *F. subtilis* does not coincide with that of *F. brasiliensis*, action taken to prevent fishing on the recruits in the beginning of the recruitment season of *F. subtilis* will not protect *F. brasiliensis* recruits because they are not present on the fishing grounds at that time.

It appears that the best time for a closed season is July and August to protect *F. subtilis* recruitment although it was felt that *F. brasiliensis* recruitment would be little affected. Another option is to increase the minimum mesh size of the cod-end during July and August. This mesh size regulation is more difficult to achieve.

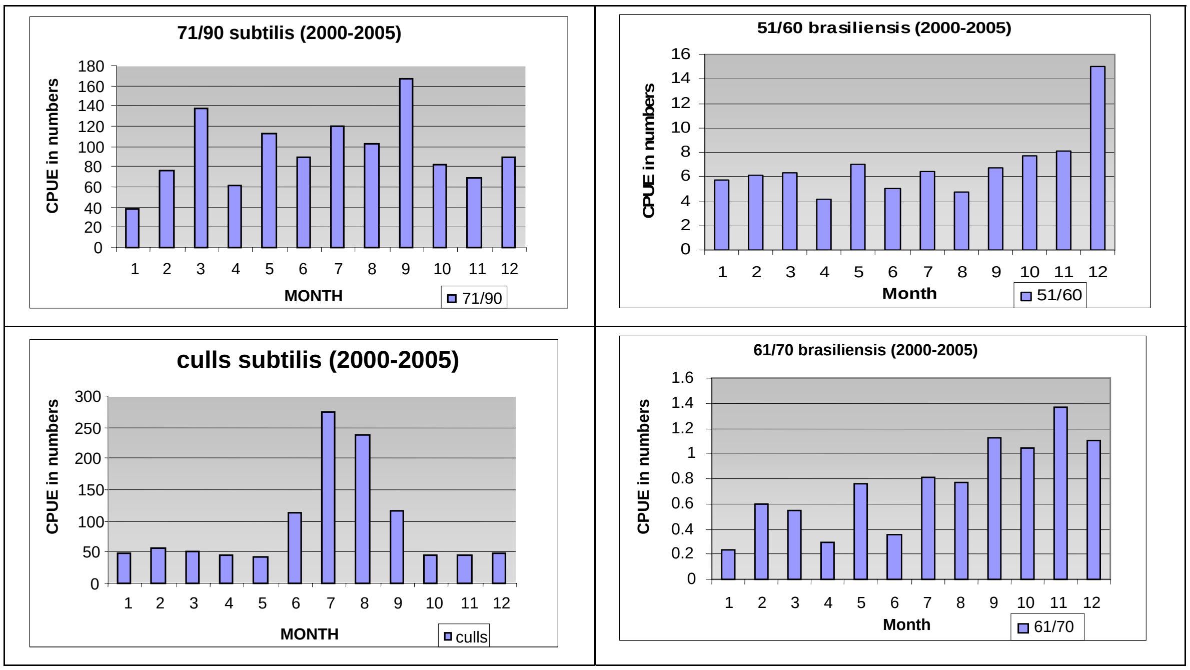


Figure 2: Catch rate in numbers for the smallest sizes of *F. subtilis* (left) and *F. brasiliensis* (right).

F. subtilis appears to recruit in July and August (lower left panel) and appears to reach the next market category by September (upper left panel). *F. brasiliensis* appears to recruit in November (lower right panel) and reaches the next largest market size by December (upper right panel).

4.4 Statistics and Research Recommendations

4.4.1 Data Quality

Only catch and effort data was available from 2000 – 2005 for *F. subtilis* and *F. brasiliensis*. Data of head-on size categories was not used, which represent only larger shrimp and not the total catch. The year 2002 was not included, because the data showed some errors.

More detailed information and data should be obtained on life history of these species; length measurements of the different size categories, growth rate estimates, factors affecting productivity and price data.

4.4.2 Research recommendations

An observer program must be implemented to collect biological data on carapace length for the various size categories of the species under study to improve assessment and clarify the best optimal period and length of a closed season.

Growth parameters must be estimated to improve assessment on these species. Growth parameters can be derived from length frequencies obtained by observers. Length data is the basis for construction of many population assessment models.

Fishing locations are also needed. These could be extracted from the Vessel Monitoring System (VMS) records. Price data of the various size categories are also needed to evaluate the consequences (benefits) of management actions.

4.5 Stock Assessment Summary

The total landings were converted in total numbers for the two penaeid species, using sampling data collected at SAIL. Catch per unit of effort (CPUE) series were calculated from 2000 – 2005 combined for each month of both species.

Graphs of catch in number per unit of effort (Figure 2) established patterns of recruitment over the year. The graphs were also used to determine an approximate growth curve (Figure 3). Knowledge of recruitment and growth was used to justify the recommendation of a closed season to protect recruitment of *F. subtilis*. The data were not sufficient to construct a growth curve for *F. brasiliensis*; more detailed length-frequency distributions for both species would enhance the ability to determine growth.

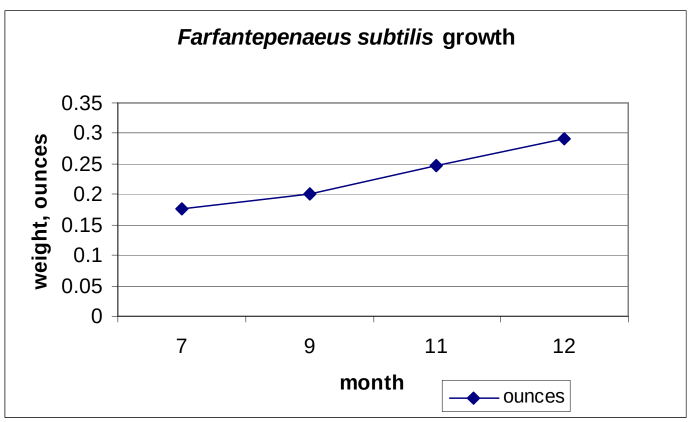


Figure 3: Estimated growth of *F. subtilis* in ounces from July to December based on following a peak in the landings data from one market category to the next over time.

4.6 Special Comments

Shrimp stocks, especially *F. brasiliensis,* are shared stocks. Therefore, joint assessment should be conducted within the Guiana–Brazil region. This was done in the past (last time, 2000) in the ad hoc working group on Shrimp and Groundfish of WECAFC. This effort should be continued through the CRFM or FAO, or both, to urge the other countries to be part of these assessments. *Xiphopenaeus kroyeri* (seabob) was introduced as a major fishery, but the impact it might have on the penaeid shrimps was not assessed yet at the regional level. This might be important, since in some countries vessels harvesting penaeid shrimp have switched to the *X. kroyeri* fishery.

4.7 Policy Summary

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

- Provides jobs (primary and secondary level)
- Create more qualitative job opportunities and reasonable incomes. Diversity of the sector is also important.
- Creates a balance of payment through export of fish and shrimp products
- Contribute to the GDP of the country
- Contribute to the national budget through fees and income tax.

The main policy is to manage the fish and shrimp resources in a sustainable way to generate revenues in the long term.

4.8 Scientific Assessment

4.8.1 Description of the fishery

Shrimp trawlers have joint owners, local and foreign. These vessels target *Farfantepenaeus brasiliensis* and *F. subtilis*. Licenses are given to these boats to operate in waters deeper than 15 fathoms over the entire EEZ.

Trips vary from 60 days to 70 days. All vessels use the double-rigged Florida or Gulf of Mexico type trawl, with engine power varying from 400 – 500 Hp. All the boats use two sets of flat nets.

4.8.2 Objective

Identify management controls, for instance introducing a closed season, which could improve the level of current biomass and the yield.

4.8.3 Data Used

Name	Description
Landings by size categories after processing	Weight for commercial size categories of each vessel from SAIL and SUJAFI (shrimp processing plants). The data covered the years 2000 – 2005.
Effort data	Effort expressed in days at sea of each vessel from SAIL and SUJAFI.
Landings in numbers for both species	The data were gathered through sampling program conducted at SAIL. In a week all commercial sizes were sampled. This is done year around. From 2005 this is difficult since the landings are low and might be processed in the weekend also.

Only data from shrimp processed in headless size category was used in the assessment

Table 1: Landings of headless shrimp from processing plants

Headless Sizes	Landings in tons									
	2000		2001		2003		2004		2005	
	das	landings	das	landings	das	landings	das	landings	das	landings
JANUARY	2,307	13.23	2,290	115.88	2,233	119.14	1,539	115.22	2,753	107.27
FEBRUARY	2,245	17.73	1,694	113.12	1,859	98.84	1,651	98.60	3,006	122.08
MARCH	2,368	32.25	1,311	57.85	1,877	90.01	1,521	75.62	2,160	94.72
APRIL	2,490	14.72	996	42.72	1,743	85.46	1,343	58.96	1,410	67.08
MAY	2,248	40.65	1,031	42.41	1,681	74.14	1,207	51.48	1,546	77.09
JUNE	2,291	18.62	944	46.92	1,619	77.76	1,334	58.63	785	31.14
JULY	2,084	17.53	844	46.65	1,610	99.15	1,382	76.85	1,321	41.54
AUGUST	1,958	26.85	1,052	29.50	1,409	77.51	1,317	55.85	1,343	42.57
SEPTEMBER	2,085	44.64	1,013	43.92	1,144	66.42	1,337	56.11	1,627	62.48
OCTOBER	2,375	45.68	1,054	102.74	1,168	72.61	1,514	58.47	1,902	84.44
NOVEMBER	2,221	40.61	1,468	89.63	1,363	87.27	1,517	62.73	1,161	90.26
DECEMBER	2,207	48.76	2,118	466.00	1,618	163.73	1,584	15.59	772	54.91

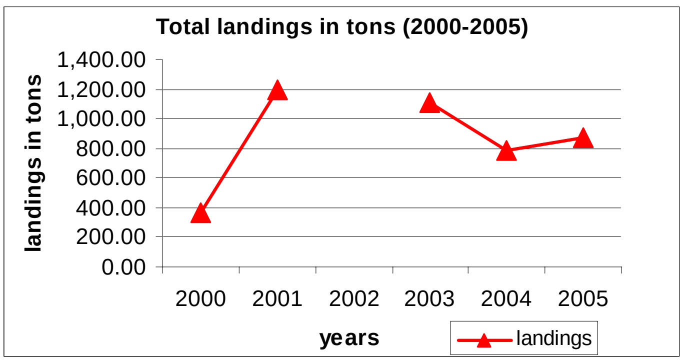


Figure 4: Total landings by year, except 2002, showing downward trend after 2001.

4.8.4 Assessment

4.8.4.1 Objectives

Determine when recruitment occurs, and how the recruits advance to larger market categories over the course of the year. Determine if there is a period of time in which a closure would protect recruits.

4.8.4.2 Method

Simple catch per unit of effort (CPUE) was calculated in numbers for *F. subtilis* and *F. brasiliensis* by size category by month, for all years combined.

4.8.4.3 Results

Tables 2 & 3 represent the CPUE values calculated for, respectively, *F. subtilis* and *F. brasiliensis*.

Table 2: CPUE in numbers of shrimp caught per day landed for *F subtilis*

F.subtilis CPUE in numbers 2000-2005 combined											
	U/10	10/15	16/20	21/25	26/30	31/40	41/50	51/60	61/70	71/90	culls
JANUARY	0.07	4.88	41.55	110.47	202.24	376.68	417.09	259.39	110.31	38.13	49.51
FEBRUARY	0.15	4.82	45.29	110.02	185.99	364.57	361.09	276.16	280.98	76.20	55.54
MARCH	0.11	4.03	44.88	100.27	148.77	312.08	250.96	286.03	259.85	137.22	50.78
APRIL	0.14	5.67	53.98	101.20	138.00	223.04	135.87	187.23	137.74	61.43	45.36
MAY	0.18	7.14	54.34	89.30	124.29	172.40	181.60	316.97	358.80	112.61	43.81
JUNE	0.09	7.06	53.36	85.80	116.35	159.24	165.37	228.20	167.25	88.63	114.54
JULY	0.12	6.70	53.21	89.33	129.08	197.91	201.08	289.14	381.78	120.24	275.49
AUGUST	0.13	4.81	38.72	72.65	119.05	184.14	166.15	212.54	364.94	102.07	237.92
SEPTEMBER	0.22	4.31	35.32	72.98	121.88	264.16	241.15	301.27	533.74	166.61	117.26
OCTOBER	0.15	5.19	40.21	99.84	180.98	342.15	334.70	345.70	494.95	81.87	45.29
NOVEMBER	0.12	4.55	43.97	109.96	206.02	349.39	367.36	365.09	650.17	68.61	44.79
DECEMBER	0.32	6.90	81.21	237.25	465.34	796.79	665.78	675.86	525.00	89.02	47.46

Table 3: CPUE in numbers of shrimp caught per day landed for *F brasiliensis.*

F.brasiliensis CPUE in numbers 2000-2005 combined									
	U/10	10/15	16/20	21/25	26/30	31/40	41/50	51/60	61/70
JANUARY	3.78	76.84	131.78	173.56	187.26	136.65	72.05	5.74	0.23
FEBRUARY	8.01	75.85	143.62	172.85	172.22	132.26	62.38	6.12	0.59
MARCH	5.68	63.48	142.32	157.54	137.75	113.21	43.35	6.33	0.55
APRIL	7.41	89.18	171.17	158.99	127.78	80.91	23.47	4.15	0.29
MAY	9.24	112.34	172.31	140.30	115.09	62.54	31.37	7.02	0.76
JUNE	4.84	111.15	169.20	134.81	107.74	57.77	28.57	5.05	0.35
JULY	6.24	105.46	168.74	140.34	119.52	71.80	34.74	6.40	0.81
AUGUST	6.79	75.79	122.80	114.14	110.23	66.80	28.70	4.71	0.77
SEPTEMBER	11.34	67.82	112.00	114.66	112.85	95.83	41.66	6.67	1.13
OCTOBER	7.61	81.74	127.51	156.86	167.58	124.12	57.82	7.66	1.04
NOVEMBER	6.42	71.61	139.42	172.75	190.77	126.75	63.46	8.09	1.37
DECEMBER	16.69	108.65	257.53	372.75	430.88	289.06	115.01	14.97	1.11

In tables 2 and 3, CPUE values (unit= numbers of shrimp caught per day at sea) are expressed for each of the peneaid species. In the tables, the sizes are getting smaller from left to right (U/10= largest size; culls= smallest size).

A series of graphs were plotted using CPUE values (Figure 5).

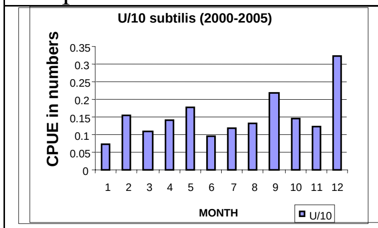
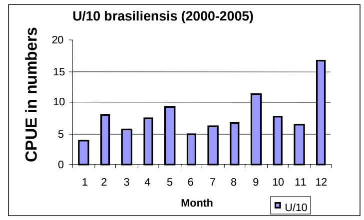
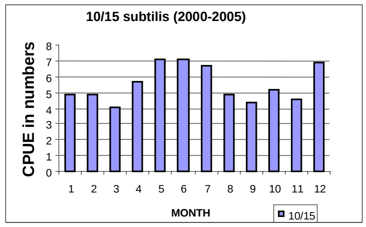
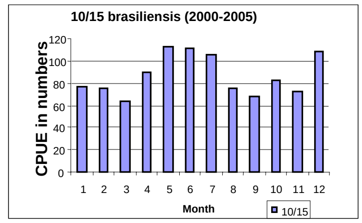
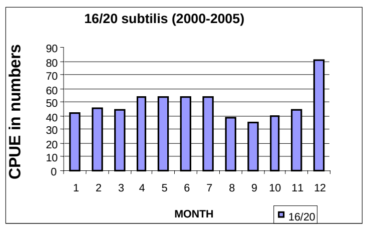
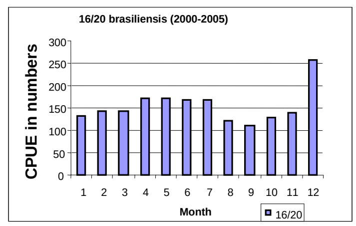
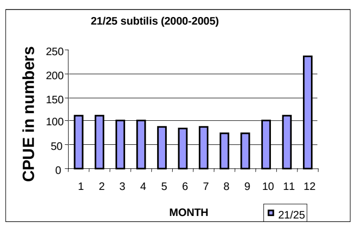
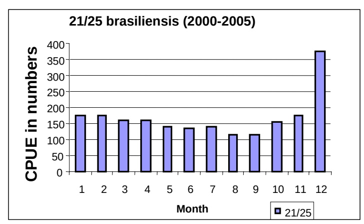
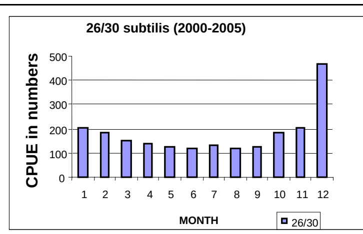
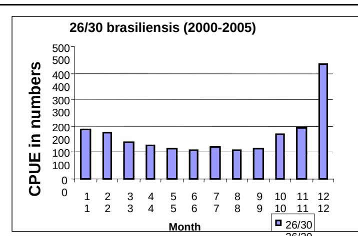
Graph of *F. subtilis*	Graph of *F. brasiliensis*
	
	
	
	
	

Figure 5a: CPUE of *F. subtilis* (left) and *F. brasiliensis* (right) by market category for each month. Data from 2000 to 2005 were combined

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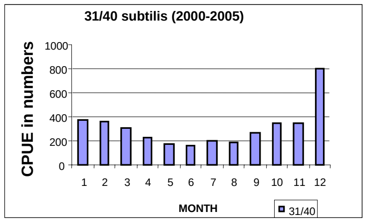

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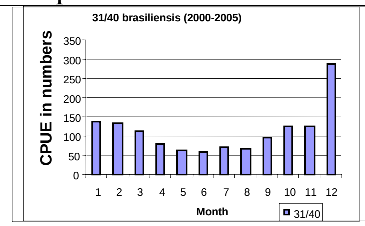

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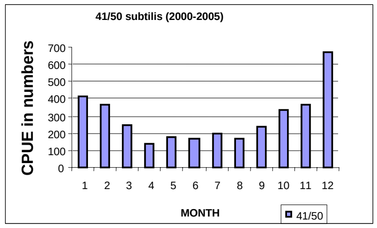

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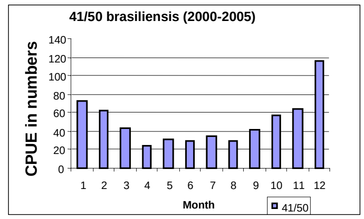

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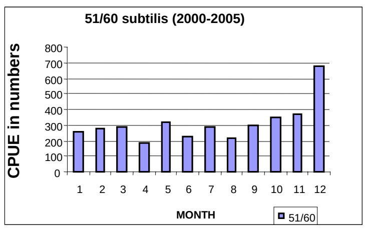

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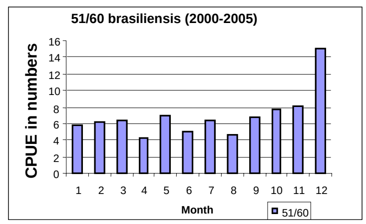

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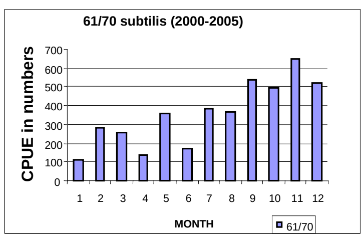

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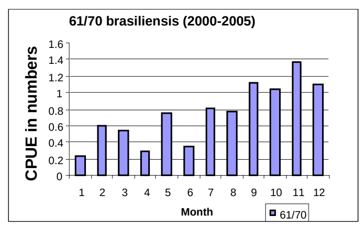

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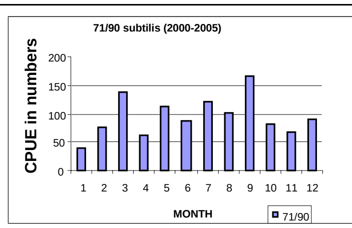

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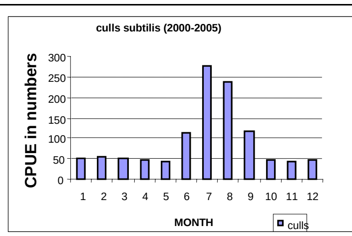

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Figure 5b: CPUE of *F. subtilis* (left) and *F. brasiliensis* (right) by market category for each month. Data from 2000 to 2005 were combined.

The smallest market category is at the bottom of each column in Figures 5a & 5b. For *F. subtilis*, there is a clear peak of recruitment around July-August seen in the CPUE of culls (small shrimp) in the bottom panel (left). This peak can be followed to September in the 71/90 count (tails per pound) data (second lowest panel), to November in the 61-70 count data, and to December in the 51-60 count data. This gives rise to the growth curve shown in Figure 3. Small *F. brasiliensis* are not captured in the Suriname shrimp fishery. The market category with the smallest shrimp, i.e., 61-70 tails per pound, shows a peak in November. The market category with 51/60 tails per pound shows a peak in December.

It appears that *F. subtilis* and *F. brasiliensis* recruit to the fishery at different times. This makes it difficult to protect the recruitment for both species based on seasonal closures. It would also appear that a closure around July and August would protect the recruits of *F. subtilis*.

4.8.4.4 Discussion

A clear period could be identified as an optimal closed season, July and August, for *F. subtilis*. Further refinement of the timing of the closure and a prediction of the impacts of a closure requires further information. Specifically, detailed length frequency data, as can be obtained from observers, is necessary. To consider economic impacts, information on prices over the course of the year is needed.

It should be noted that seasonal closures can have two effects: 1) to reduce fishing effort and thus fishing mortality, and 2) to protect fast-growing, young animals until they reach a larger and more valuable size. Thus, a seasonal closure around July and August would reduce fishing mortality for both species while protecting recruitment of *F. subtilis*.

4.8.5 Management

Previous assessment of these stocks carried out by WECAFC in 2000 (FAO 2001), had concluded that the shrimp stocks are fully exploited. Therefore, it is recommended that management measures should be taken as soon as possible to rebuild the stock and improve yields. Two options for accomplishing this are to institute a closed season and to require the use of larger mesh size trawls during part or all of the year.

4.9 References

FAO. (2000). Suriname shrimp and groundfish assessment, In Report of the Third Workshop on the Assessment of Shrimp and Groundfish Fisheries on the Brazil-Guianas Shelf, Belem, Brazil, 24 May – 10 June, 1999. *FAO Fisheries Report* No. **628**. Rome. 206p.

FAO. (2001). Suriname shrimp and groundfish assessment, In Report of the Meeting of Fisheries Managers and ministers of the WECAFC Ad Hoc Working Group on Shrimp and Groundfish resources in Brazil-Guianas Shelf, Port of Spain, Trinidad and Tobago, 26-29 March 2001. *FAO Fisheries Report* No. **650**. 61p.

FAO. (2001). Suriname shrimp and groundfish assessment, In Regional reviews and national management reports: Fourth workshop on the Assessment of Shrimp and Groundfish Fisheries on the Brazil-Guianas Shelf, Cumana, Venezuela, 2-13 October 2000. *FAO Fisheries Report* No. **651**. 152p.

Appendix 5: Report for the Reef and Slope Fish Resource Working Group (RSWG)

Chairman: Ramon A. Carcamo (Belize)
Consultant: David Die PhD.
Maren Headley (CRFM Secretariat)

A. OVERVIEW

At the First Annual CRFM Scientific Meeting held in St. Vincent and the Grenadines in 2004, the Reef and Slope Fish Working Group conducted some analysis on the data from the Red hind (*Epinephelus guttatus*) fishery. The data were submitted by St. Vincent and the Grenadines and the working group was composed of Yolanda Babb, Sophia Punnett, Paul Medley and Susan Singh-Renton. However, it was noted that a quantitative assessment of the fishery was not possible because of time and data constraints. Nevertheless, trends in landings and size frequency of catch were examined which provided some preliminary results.

During the Second Annual CRFM Scientific Meeting held in Trinidad & Tobago the Red hind fishery was submitted again for consideration by the Third Annual CRFM Scientific Meeting. In addition other fisheries were submitted for consideration in the analysis process *viz* the Nassau grouper (*Epinephelus striatus*) and Mutton snapper (*Lutjanus analis*) fisheries of Belize.

In this Third Annual CRFM Scientific Meeting the RSWG was then responsible to conduct analyses on data from Nassau grouper, Mutton snapper, Red hind and Lane snapper (*Lutjanus synagris*). The RSWG for the third annual meeting was composed of Dr. David Die, Ramon Carcamo and Ms. Maren Headley.

Data assessment:

1. At the beginning of the session for the RSWG the species rapporteur questioned the availability of data for the Lane snapper. It was noted that it was not clear which country expressed a desire for the Lane snapper fishery to be assessed. Therefore, due to the absence of data it was removed for analysis during the sessions.

2. The data for the Nassau grouper fishery and Mutton snapper fishery of Belize were then reviewed by the RSWG.

3. The Nassau grouper data were gathered by conducting underwater visual surveys at several spawning aggregation sites in Belize. However, due to the nature of the data set and the time series it was not possible to conduct a quantitative stock assessment. Therefore, the data were used to conduct a Multi-factor ANOVA analysis to determine any trends or variations with respect to different factors such as site, quarter, management and moon phase. Also other basic statistical descriptive analyses were possible.

4. Preliminary results were obtained that could explain some activities that occur at the spawning aggregation which will assist in better monitoring the spawning aggregation sites.

5. It was then possible to propose management and policy recommendations for the Belize Nassau grouper fishery.

6. While the Mutton snapper dataset was also analyzed it was not possible to formalize any significant recommendations due to the time limitations which the RSWG had, since the responsibilities of the Chairperson and species rapporteur were conducted by one person.

7. The recommendations coming out of the analyses presented in the species report will be submitted to the country for consideration.

B. FISHERIES REPORTS

1.0 The Nassau Grouper (*Epinephelus striatus*) Fishery of Belize

1.1 Management Objectives

The Nassau grouper fishery of Belize is the most important target species in the Deep Slope Fishes category. Belize Fisheries Department (BFD) (2004) noted the following management objectives for this fishery:

- Control fishing effort at or less than present levels;
- Maximize catches for domestic and export markets, while aiming to achieve sustainability through conservation;
- Limit fishing effort on spawning aggregations and protect areas where these species normally inhabit during the early life stages of their development;
- Promote mariculture development, particularly for the groupers and to integrate traditional fishermen into this field.

Due to the heavy commercial exploitation of the Nassau grouper, the Belize Fisheries Department in 2002, declared 11 aggregation sites as protected areas, these sites were also previously considered as multi-species aggregation sites (Paz and Grimshaw, 2001). In addition, a Belize Spawning Aggregation Working Group (SPAG) was established for the specific task of monitoring these 11 spawning sites.

1.2 Status of Stocks

The Nassau Grouper (*Epinephelus striatus*) is the second most commonly caught, but and the most valuable finfish in Belize. However the catches have dropped considerably (BFD, 2004). Caye Glory was once Belize's most productive grouper bank, where catches reached 2 tons per day in the late 1960's. Production significantly declined over the last few decades as a result of continuous and intensive fishing at the site (Craig, 1969; Paz and Grimshaw, 2001; Sala *et. al.*, 2001). Fishers have observed that spawning females have been increasingly getting smaller. Additionally, catches of groupers have decreased from 45 MT (approximately) to less than 14 MT (approximately) during the 1990s (BFD, 2004).

In 2007, spawning aggregation data collected by SPAG was analysed. The results indicate that the protection provided to the spawning sites has had a detectable positive effect on the abundance of Nassau grouper. It is not known, however, whether the Nassau grouper stock which occurs within Belizean waters is overfished.

1.3 Management Advice

Although the protection of selected spawning aggregation sites seemed to have had a positive impact on stocks of Nassau grouper, the impact on other species could not be determined. Continued monitoring of these sites by SPAG, although costly, has proven to be a useful tool for the evaluation of these effects. Thus it is essential that such monitoring continues.

To enforce the protection of the spawning sites it is necessary for the Fisheries Department to increase its presence at these sites especially during spawning seasons. The Fisheries Department needs to continue to work with its partners and stakeholders to be able to efficiently manage these spawning aggregation sites. It is also recommended that the Fisheries Department should embark on a national campaign to sensitize and educate the general public especially the fishing communities about the status of the spawning sites in Belize. It is also recommended that all known multi-species spawning aggregation sites in Belize remain closed to fishing.

The lack of comprehensive information on stock status for Nassau grouper and other important species requires a precautionary approach to management. Although current management protects part of the spawning stock, there are still some spawning sites that continue to be open to fishing. Additionally, fish outside spawning sites are not protected. If the Government was to consider it necessary to implement additional precautionary measures to improve the stock status of these species, it should evaluate the benefits and costs of imposing a size limit and/or seasonal closures for Nassau grouper and other associated species.

1.4 Statistics and Research Recommendations

1.4.1 Data Quality

The coordination provided by SPAG has been valuable in providing the data used in the 2007 analysis of Nassau grouper, and is a reflection of the success of the program in standardizing the methods of counting and measuring fish. Examination of these data however, shows that the number of samples obtained in certain sites is inadequate for evaluating the effects of management on such sites. Further examination of the database could provide guidance on how to make the current sampling effort a more effective tool for monitoring the effects of management and for the evaluation of stock status.

1.4.2 Research

Analyses of the SPAG database should be conducted for other species of fish that also aggregate at the spawning sites to evaluate the effect of protection on their stocks. Additionally, biological data on snappers and groupers, collected at the landing sites, should be used in future evaluations of stock status.

1.5 Stock Assessment Summary

The effect of management (protection of spawning sites) on the abundance of Nassau grouper was evaluated by analyzing the SPAG database. Analyses were conducted on the estimated size (maximum number of fish observed, and biomass of such fish) of Nassau grouper aggregations and on the presence/absence of Nassau grouper in the aggregation sites.
Analysis of variance tests showed that:

a. Nassau grouper aggregation size (biomass and number of fish) varied significantly between sites and quarter of the year, but not between moon phases or between the pre-management period (before 2002) and the post management period (2002 and after).
b. In the case of presence/absence of Nassau grouper, quarter, site, and management period were significant factors in explaining the observed variability.

It is possible that the analyses examining aggregation size did not detect the effect of management because of the high variability in the data. The size of the aggregations varied considerably, even at the peak spawning times, thus making comparison of the pre-management and post-management size of aggregations difficult. On the other hand the presence/absence data had less variability and, in this case, management period was found to have a significant effect. It should be noted that this is a common result in data sets where the probability of having observations with a zero count is large, as it is the case with underwater visual censuses.

The Nassau groupers from Belize are thought to be migratory species, but they exhibit high site-fidelity, spawning at exactly the same location and on the same days of the lunar calendar year after year. Assuming the Belizean Nassau grouper is shared with neighbouring countries, a complete assessment would require data from all fisheries operating throughout the entire range of the stock.

1.6 Special Comments

The data for red hind were reviewed during the meeting but were not analysed because of the low number of observations present in the SPAG database.

1.7 Policy Summary

The Government of Belize and the Belize Fisheries Department is committed to the conservation, protection and sustainable use of the aquatic resources of Belize. The participation of stakeholders and partners is an essential factor when considering the management of the resource and the socio-economic impact it would have on those dependent livelihoods. The Fisheries Department is involved in conducting basic research, education awareness, marine environmental monitoring, policy development, marine reserves management and enforcement of the Fisheries Regulations.

The Government has recognized that "Open Access" and over-fishing significantly negatively affect the sustainability of any fishery. Therefore, the Government has invested in the design, implementation and utilization of marine reserves as a management tool for the protection of critical habitats and spawning aggregation sites for species of ecological importance. In 2002, the Government of Belize realized that it did not have enough information to assess the status of the Nassau grouper fishery even though certain reports were indicating that the fishery would collapse in 2011. The Government adopted a precautionary approach policy and closed 11 spawning aggregation sites.

The current assessments have addressed some policy objectives of the Fisheries Department of Belize regarding the status and management of Nassau grouper stock at the spawning aggregation sites. The Government is committed to continue working with its partners and stakeholders to increase monitoring of spawning aggregation sites and seek alternative fishing practices for those displaced from traditional fisheries. The Government will also continue to provide the services it has been providing to the public especially to the fishers of Belize.

1.8 Scientific Assessments

1.8.1 Background or Descriptions of the Fishery

The deep slope and bank fishery is a small-scale artisanal one targeting mainly snappers and groupers using monofilament handlines. A smaller amount is also taken by larger decked vessels using electric reels. Grouper and snapper fisheries have been exploited for generations by local fishermen, and form the basis for the finfish export industry in Belize. Fishing operations usually target annual spawning aggregations which occur at predictable locations (BFD, 2004).

The fishing fleet is composed of open boats, sloops and canoes (mostly less than 10 m in length). Open boats are made of wood or fiberglass, 4.3-7.6 m in length, propelled by outboard engines. Sloops are mostly wooden vessels up to 10 m in length, equipped with sails and smaller auxiliary outboard engines. Large dug-out canoes are used in southern regions, and are equipped with small engines and oars, primarily for fishing finfish using handlines or nets.

The shelf area is a complex system consisting of the largest barrier reef in the Atlantic (220 m in length), three offshore atolls- (Lighthouse Reef which contains Blue Hole, the Turneffe Islands and Glovers Reef), patch reefs, seagrass beds, several hundreds cays of sand and mangrove, extensive mangrove forests, coastal lagoons and estuaries. The total area fished is estimated to be about 4700 km^2 within a depth range of 1.5-10 m (BFD, 2004). Commercial fishing for groupers is prohibited in 11 known spawning areas and two sites have been made accessible for commercial fishing (special licences are granted to traditional fishers). These sites are Maugre Caye at Turneffe Islands and Northern Two Cayes at Lighthouse Reef.

1.8.2 Overall Assessment Objectives

To assess the influence of management, moon phase, quarter and site on the abundance of Nassau grouper spawning aggregations.

1.8.3 Data Used

The Belize Fisheries Department, in collaboration with local and international NGOs, conducted a number of visual surveys over an extended period beginning in the late 1990s (1998-2005). Underwater visual surveys were conducted at 22 spawning aggregation sites around the time of the full moon (usually a few days before or after the full moon). The survey teams usually consisted of four individuals using SCUBA. Underwater slates were used to record the data. The data collected included; total number of Nassau groupers sighted by size class, depth of spawning aggregations (SPAGs), wind direction, water temperature, and GPS positions of the SPAGs. The Belize SPAG working group has been responsible for the management of the data and the database.

Data	Sampling details
Spawning aggregation underwater survey data.	Visual underwater survey data collected during 1998-2005, by various NGOs and the Belize Fisheries Department. Twenty-two spawning aggregation sites were surveyed.

1.8.4. Assessment 1

<u>1.8.4.1 Objective</u>

Specific objective of the analysis.

General management objectives used to guide the 2007 analysis included:

i) Determination of the abundance of Nassau Grouper at spawning aggregation sites.
ii) Determination of the effectiveness of the implementation of the current measure of spawning site protection introduced since 2002.
iii) Determination of the population structure of the spawning aggregations.

<u>1.8.4.2 Method/Models/data</u>

In order to evaluate the effect of moon phase on the presence of aggregations, a variable representing moon light was created by using an approximate formula:

Moonlight=COS(RADIANS(360/29.530588*(Date of Full Moon-Date))); where Date of Full Moon corresponded to a day within the sampling period where a full moon was present (13 Jan 1998). Moon light was then used to define moon phases and moon cycles.

Four moon phases were defined:

- Ascendant -0.3 < Moonlight(date) <0.7 and Moonlight(date)>Moonlight(date+1)
- Full Moonlight(date) > 0.7
- Descendent 0.7 < Moonlight(date) <-0.3 and Moonlight(date)<Moonlight(date+1)
- New Moonlight(date) < -0.3

Moon cycles were defined as beginning with the ascendant phase and finishing with the new moon. The first moon cycle defined, began on the 4/1/1998 and the last one defined, cycle number 99, began on 6/12/2005.

Three sites were selected as important for the Nassau grouper analysis on the basis of the number of samples obtained in them and the frequency of occurrence of Nassau groupers during the underwater visual census (UVC). These sites were, Gladden Spit, Sanbore and Halfmoon Caye. At these sites, only eight sampling trips were carried out during the ascending phase of the moon, and therefore these samples were eliminated from the analysis. Of the 99 moon-cycles that occurred during the sampling period, UVC samples were obtained for 54 of them with the majority of samples (83%) being obtained for the first two quarters of the year, (Jan-Mar and Apr-Jun). Few samples were obtained in the new moon (9%) and most occurred during the full moon or descending moon.

The analysis of abundance proceeded by assuming that each aggregation of Nassau grouper has a single cycle during each moon cycle. Furthermore it was assumed that the aggregation could be characterized by the sample obtained for the dive where the most fish were observed. This assumes that the aggregation reaches a single peak during the moon cycle and that this peak can be used to characterize the abundance of fish participating in the aggregation. Three measures of abundance were obtained from the samples identified as the peak samples: the total count of fish, the total number of mature fish (>50 cm) and the total biomass of fish. Total biomass was obtained by converting the length frequency distributions of fish for which measurements were made underwater and transforming them into weight frequencies with the aid of the length-weight relationship published by Sadovy and Eklund (1999). These weight frequencies were then raised to the total count observed for that dive by using the ratio of measured/counted. In cases where no fish was measured, it was assumed that the average fish weight was 5 kg. To account for the fact that moon cycles with fewer samples would produce more uncertain estimates of the abundance levels describing the peak of the aggregation, the number of samples (dives) made per lunar cycle was used as a weighting factor in the analysis of abundance.

1.8.4.3 Results

Of the four factors tested using ANOVA, i.e. management, moonphase, quarter and site, site and quarter were highly significant in explaining the variability of the total number of fish observed among the three sites. Moonphase was found to be slightly significant and management was insignificant (Table 1). A similar analysis of the total weight of fish showed only site and quarter to be significant factors affecting fish weight (Table 2). In the case of presence/absence of Nassau grouper, quarter, site, and management period were significant factors in explaining the observed variability (Table 3).

Table 1: ANOVA results of fit with the dependent variable = ' LNTOTCOU' (total number of fish). Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1205.575(a)	8	150.697	15.354	.000
Intercept	259.885	1	259.885	26.478	.000
MANAGEME	1.790	1	1.790	.182	.672

QUARTER	371.700	3	123.900	12.624	.000
MOONPHAS	69.344	2	34.672	3.533	.039
SITE	432.463	2	216.231	22.031	.000
Error	392.600	40	9.815		
Total	4434.257	49			
Corrected Total	1598.174	48			

a R Squared = .754 (Adjusted R Squared = .705)
b Weighted Least Squares Regression - Weighted by NUMDIVES

Table 2: ANOVA results of fit with the dependent variable = 'LNAGWT' (total weight of fish). Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1458.290(a)	8	182.286	8.926	.000
Intercept	606.573	1	606.573	29.702	.000
MANAGEME	.074	1	.074	.004	.952
QUARTER	399.279	3	133.093	6.517	.001
MOONPHAS	120.963	2	60.481	2.962	.063
SITE	610.620	2	305.310	14.950	.000
Error	796.453	39	20.422		
Total	9348.278	48			
Corrected Total	2254.742	47			

a R Squared = .647 (Adjusted R Squared = .574)
b Weighted Least Squares Regression - Weighted by NUMDIVES

Table 3: Outputs of GLM, with dependent variable = 'occurr' (presence/absence of Nassau grouper).

(a) Analysis of deviance table

	Df	Deviance	Residual Df	Residual Deviance
NULL			409	287.1359
Site	2	29.50004	407	257.6359
Quarter	3	35.91634	404	221.7195
management	1	6.98975	403	214.7298

(b) Table of coefficients

	Value	Std. Error	t value
(Intercept)	-0.9682530	0.14874114	-6.509651
Site1	0.1214103	0.09528027	1.274244
Site2	0.1092166	0.05909754	1.848073
quarter1	-0.4946837	0.09573047	-5.167464
quarter2	-0.2403903	0.11115120	-2.162732
quarter3	0.1312045	0.06268712	2.093006
management	0.2520435	0.10051563	2.507506

1.8.4.4 Discussion

Site and quarter were found to be the most important factors influencing aggregation size and biomass. It is possible that the analyses examining aggregation size did not detect the effect of management because of the high variability in the data. The size of the aggregations varied considerably, even at the peak spawning times, thus making comparison of the pre-management and post-management size of aggregations difficult. On the other hand the presence/absence data had less variability and, in this case, management period was found to have a significant effect. It should be noted that this is a common result in data sets where the probability of having observations with a zero count is large, as it is the case with underwater visual censuses.

These results suggest that the protection provided to the spawning sites has had some positive effect on the abundance of Nassau grouper. It is not known, however, whether the Nassau grouper stock which occurs within Belizean waters is overfished.

1.8.5 Management

Even though the analyses indicated that there was a positive effect on the abundance of Nassau groupers due to the protection of SPAG sites, it is not known whether the Nassau grouper stock is overfished, therefore, a precautionary management approach is necessary.

1.9 References

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

A. OVERVIEW

As agreed at the plenary session of the Second Annual CRFM Scientific meeting held in Trinidad and Tobago in 2006, the Large Pelagic Fisheries Working Group for this the Third Scientific meeting was comprised of Christopher Parker (Barbados) as Chairman and species rapporteur for wahoo and Ms. Louanna Martin (Trinidad and Tobago) as rapporteur for King Mackerel. Ms. Elizabeth Mohammed, species rapporteur for Crevalle Jack was not present at the meeting.

At this meeting, Dr. David Die was the consultant primarily assigned to work with the LPWG. However additional advice was obtained for specific issues from the other consultants, mainly Mr. Bruce Lauckner, Dr. Clay Porch and Dr. Susan Singh-Renton. The group met initially to review any significant developments that had occurred during the intersessional period and other topics of general relevance regarding the goals, mandate and operational procedures for the working group.

Assessments

- Due to the absence of Ms. Elizabeth Mohammed, the species rapporteur for Crevalle Jack, it was regrettably not possible for an assessment of this species to be conducted this year.
- Since no relevant additional information had been obtained during the intersessional period that could be used to add to the information regarding the status of the dolphinfish stocks assessed in 2006, it was agreed that this species would not be reassessed this year.
- It was agreed that in keeping with the recommendation made at the 2006 meeting, an assessment of the status of the wahoo stock should be conducted. However, as no additional information that could be used in conducting any other type of stock assessment of the wahoo stock was available, it was agreed that this year's assessment would be limited to a standardization of catch rates using a Linear Model for the period 1996 to 2006. It was also decided that only the datasets for the St. Lucia pirogue and Barbados moses and dayboat fleets would be used. The rationale for this decision will be discussed in the relevant assessment report.
- It was decided that the 2006 assessment of king mackerel would be updated using new length frequency data collected in 2006-2007 as recommended by the 2006 meeting.

Other issues

- It was noted that although a number of large pelagic species are of commercial interest to CRFM member countries, only a few of these species have so far been slated for stock assessments and fewer have actually been assessed. It was noted that dolphin and wahoo in particular have been the subject of repeated stock assessments by CRFM, but other species like blackfin tuna, have never been assessed. Member countries should be urged to carefully consider which species they may want to submit to the Large Pelagic Fishery Resource working group for stock assessment. To facilitate this decision-making process it was agreed that during the intersessional period the Chairman would circulate a list of species of possible interest to member countries seeking their input on this matter.
- CRFM member countries are not the only harvesters of the stocks examined by the pelagic working group and oftentimes do not catch the majority of the biomass of the migratory or highly migratory stocks being assessed. However CRFM countries are

obliged by being signatories to a number of international agreements to participate in assessing these fish stocks within international forums such as ICCAT and WECAFC. Unfortunately these international organizations have not conducted assessments of these stocks and are unlikely to conduct them in the near future. To improve the information on these stocks provided to CRFM countries a number of possible mechanisms exist:

1. Non-CRFM harvesting entities and other regional organizations may be included in the CRFM assessments. This can be done by:
    - CRFM continuing to formally invite the participation of non-CRFM entities in the CRFM Scientific meetings
    - Utilize existing bi-lateral agreements that exist between CRFM and non-CRFM members to effect joint stocks assessments. The results of these joint assessments in the form of either aggregated data or even overall results will offer additional invaluable information on the status of the species in the region.
2. Promote the assessments of pelagic resources of interest to CRFM by regional organizations. This can be done by:
    - Requesting WECAFC, whose membership embraces most of the major non-CRFM harvesting nations, to undertake the assessments of pelagic resources of interest to CRFM via new pelagic species stock assessment working groups such as that formulated to assess flyingfish.
    - CRFM could present the results of their assessment of species that are under ICCAT's mandate (eg wahoo) at the meeting of the small tunas working group to raise the profiles of these stocks within ICCAT

- The issue of mechanisms for sharing raw data to facilitate regional stock assessments was also discussed. It was noted that the option of maintaining a permanent regional database that would house cleaned national datasets for use in multilateral stock assessments has been discussed within several CRFM forums but has hitherto not been developed. A final decision on the feasibility of establishing such a regional-database should be taken. If countries are opposed to having their raw data stored in a permanent regional-database but still want to participate in regional assessments it would be acceptable to share their cleaned raw datasets only for the duration of the assessment meeting. Only for the purposes of the meeting will the national raw databases be combined to form what would be a temporary regional database that will be destroyed at the end of the meeting. However, the caveat to this approach is that the countries must maintain their raw datasets in a standard format that would facilitate a simplified merging process at the time of the assessment meeting. It would simply be unacceptable to devote time each year to re-cleaning and reformatting the national datasets for use in the assessments.
- It was suggested that if there has been a lack of inter-sessional activities of the Resource Working Groups, the reasons should be noted. It was also suggested that the management actions, which have been taken from the recommendations of the Working Groups should be documented and if they have not been implemented, the reasons should be noted.
- Finally it was noted that the CRFM should explain the precise status of the CARIFIS data management program as most countries have not been able to use this program. As a result national data is presented in many formats such as Excel, CARIFIS and TIP and as such must be streamlined into a common format for analysis.
- Given the points listed above it was agreed that decisions on the stocks to be assessed, the timing for species stock assessments and indeed the forums for these assessments should be taken at the plenary.

B. FISHERIES REPORTS

1.0 Assessment of the king mackerel (*Scomberomorus cavalla*) Fishery of Trinidad and Tobago

1.1 Management objectives

In Trinidad and Tobago, king mackerel (*Scomberomorus cavalla*) is considered part of a multi-species unit of coastal pelagic species taken by a combination of gears and fleets. The fishery lands Serra Spanish mackerel (*S. brasiliensis*), Crevalle jack (*Caranx hippos*) and a number of shark species among others. National management objectives for coastal pelagics have not been formally adopted but focus on 'maintaining the sustainability of the resources' (see *Draft Policy for the Fisheries Sector of Trinidad and Tobago* and draft fisheries management plans).

In Guyana, the management objectives for the large pelagic fishery are 'to develop the capacity for maximising catches of large pelagic species that inhabit or migrate through the country's EEZ; and to establish management linkages with international regulatory bodies, such as ICCAT, in order to access vital information to properly manage these fisheries'.

Clarification of the management objectives is requested by the group for these and other countries sharing this stock, including any specific reference points adopted by states to quantify their objectives and guide management decision making.

1.2 Status of stocks

The working group assumed a 'southern Caribbean' stock of king mackerel inhabiting at least the waters of Trinidad and Tobago, Venezuela and Guyana. With large catches also recorded in Brazil, and small catches in Grenada, it is possible that the unit stock extends more widely along the shelf waters of the S. American coast. Due to the relatively low catches in central Caribbean waters, away from the continental shelves, the southern stock was assumed to form a separate unit from those stocks found in the coastal waters of the Gulf of Mexico, the Southern US coast and the Greater Antilles.

A similar result to that obtained in 2006 was obtained in 2007 and the updated stock assessment for king mackerel remains inconclusive. The status of the stock as measured by the target reference point (F0.1) and limit reference point (F20%SPR) varies greatly depending on the growth/natural mortality parameter combination used in the analysis. The working group was unable to significantly reduce this uncertainty during 2007; in fact the review of growth data from other neighbouring stocks suggested that there is greater uncertainty in growth than reported in 2006. It is imperative that such uncertainty is reduced before similar assessments are updated.

The comparison of mortality rates between the 1996-98 period and the 2006-2007 period, however, suggests that there has not been a significant change in fishing mortality in the last 10 years. The fact that total catches (as estimated from FAO statistics) have fluctuated without a trend during this period is consistent with a stock that is being harvested sustainably. Unfortunately it is not known whether the stock is over fished or not, thus the current exploitation level may be sustainable, but may not be the level desired by management.

1.3 Management advice

The king mackerel resource is a valuable resource for Trinidad and Tobago with annual landings valued at TT$10M. The uncertainty in stock status forces management to take a precautionary approach. Current levels of fishing effort should not be increased. If a decline in catches or catch rates is detected the CRFM should facilitate prompt collaboration among the countries fishing the stock to develop consensus on the management strategies to be adopted. Finally, the participation at CRFM assessment meetings of scientists from other countries that harvest the same stock should be encouraged, as to also provide additional assessment data. It is quite likely that the data that these countries can provide can significantly reduce the uncertainty in the evaluation of stock status.

1.4 Statistics and research recommendations

1.4.1 Data quality

The 2006 assessment made some important recommendations, many of which remain relevant:

- Catch and effort data are available for Trinidad and Tobago at the 'raw' trip interview level, but not for the other countries. Trinidad and Tobago data records also exist for the years prior to 1991 in the form of the original paper log sheets, most of which have not yet been computerised. Entering these records would enable biomass dynamic analyses to be conducted on the trends in abundance over time, and provide an independent estimate of the state of stocks. Such data should be made available before the next catch/effort assessment is attempted.

- Detailed 'raw' catch-effort data including gear type, and relevant fishing effort measures (e.g. hours fishing, manpower, number of hooks, gill net numbers and lengths etc) should also be sought by the working group for the other countries sharing the stock (including those available from other neighbouring countries that are members of ICCAT and which have logbook or on-board observer programs e.g. USA, Venezuela and Brazil). Catch per unit of fishing effort data should include trip records from fishing gears which target king mackerel (or other pelagic fish species) for trips even when the species was not caught, thus the data should also include records of zero catch.

- Information is also required on the histories of developments in the fishing fleets and fishing methods in each country. Any significant changes in fishing practices or the power of vessels, or locations fished etc can change the 'catchability' of the fleet and need to be accounted for in assessments.

- To strengthen the assessment, length frequencies should also be sought from the other countries sharing the stock. Such information may clarify the migration patterns of the stock and would provide independent estimates of the fishing mortality rate.

1.4.2 Research

- Due to the critical importance of basing stock assessment and management on a clearly defined unit stock, a better understanding is required of the stock range and migration patterns of the species, and the validity of the 'Southern Caribbean' stock assumption in this analysis. If more comprehensive literature searches do not resolve the matter, genetic or other research should be conducted to clarify the stock distributions.

- To reduce uncertainty in the growth and mortality rate parameters, otoliths or other 'hard parts' methods of ageing king mackerel may also be investigated, e.g. at the IMA growth laboratory. The IMA growth laboratory should seek to expand the collection of hard parts for this stock.

- Monitoring of the fishery and research on its biology should be undertaken to reduce the uncertainty in population parameters by continuing to obtain fish size data to allow for future monitoring of mortality rates.

- Monitoring and collation of historical catch per unit of fishing effort should be intensified to be able to provide alternative sources of data for stock assessments.

- Another assessment of the status of the stock may be recommended provided that pertinent data and/or information are acquired that would result in a more refined stock analysis.

1.5 Stock assessment summary

- Catches in recent years have been at historical high levels of 4-7 000 t. In most years the largest catches are reported as being taken by Venezuela and Brazil.
- Growth parameters obtained in the 2006 assessment show a much greater growth rate than those estimated for the neighbouring stocks of the Gulf of Mexico and the US South Atlantic (Brooks and Ortiz 2004). Although such differences may be real their presence suggests that uncertainty in growth parameters is greater than that reported in 2006. It is imperative that such uncertainty is reduced before similar assessments are conducted.
- In 2007 the Working group decided to update the 2006 assessment by expanding the range of possible growth parameters and by using the length frequency data collected during 2006-2007 to estimate recent mortality rates. The following conclusions were reached from this analysis:
  - The updated stock assessment for king mackerel remains inconclusive. The status of the stock as measured by the target reference point (F0.1) and the limit reference point, (F20%SPR) varies greatly depending on the growth/natural mortality parameter combination used in the analysis. Estimated fishing mortality rates were anywhere from well above the limit F20%SPR reference point (indicating severe overfishing) to below the target reference point of F0.1 (indicating there is room for expansion) depending on which of the sets of growth parameters and corresponding natural mortality estimates were used (Table 1).
  - The comparison of mortality rates between the 1996-98 period and the 2006-2007 period estimated for any particular set of growth parameters, however, suggests that there has not been a significant change in fishing mortality in the last 10 years. The fact that total catches (as estimated from FAO statistics) have fluctuated without a trend during this period is consistent with a stock that is being harvested sustainably.
  - It is not known whether the stock is over fished or not, thus the current exploitation level may be sustainable, but may not be at the level desired by management. The status of the stock remains uncertain, however, the possibility that fishing mortality is already above the limit reference point exits, therefore management should be precautionary and invest the necessary resources to reduce the uncertainty in the evaluation of stock status by supporting the research recommendations outlined in this report.

Table 1: Comparison of estimated fishing mortality rates (2006-2007) with the estimated 'threshold' or limit reference point levels, for the three possible sets of growth parameters. Values in brackets show fishing mortality as percentages of the reference points. Percentages above 100% indicate overfishing.

Model fit	Limit reference point, $F_{20\%SPR}$	Estimated fishing mortality rate, F (indicator of fishing pressure on the stock)	
		For years 1996-98	For the year June '06-June '07
Low $L_{infinity}$ (2006)	0.80	0.67 (84%)	0.82 (103%)
Med. $L_{infinity}$ (2006)	0.66	1.19 (180%)	1.13 (171%)
Gulf of Mexico & Florida	0.55		0.18 (32%)

1.6 Special comments

None.

1.7 Policy summary

The working group agrees with the Trinidad and Tobago government (Fisheries Division, 1992) and ICCAT positions that management for the coastal pelagics should be coordinated among neighbouring countries sharing the stock. Options for assessing and managing the stock in collaboration with Venezuela, Brazil and any other relevant countries should be explored, by actively encouraging ICCAT and WECAFC to provide data and expertise for the assessments of these stocks.

1.8 Scientific Assessments

1.8.1 Background

Estimation of growth rates and mortality rates, and analytical yield per recruit modelling were attempted for the fishery at the Second Annual CRFM Scientific Meeting, held in March 2006 (Martin and Hoggarth, 2006). The 2006 assessment was inconclusive and recommended re-assessment of the fishery.

1.8.2 Overall Assessment Objectives

An attempt was made to improve the results of the assessment carried out at the Second Annual CRFM Scientific Meeting.

1.8.3 Data used

Following the recommendation of the Second Annual CRFM Scientific Meeting; length frequency data collected from the line gears (a la vive, trolling, switchering and banking) operating in Trinidad over the period June 2006 to June 2007 were utilised in this assessment update.

1.8.4 Assessment 1

1.8.4.1 Objective - Estimation of mortality rates

Total mortality rates (Z) for king mackerel were estimated from the length frequency data. Total mortality rates are used to estimate the fishing mortality rate (F) by subtracting the natural mortality rate (M).

1.8.4.2 Method/Models/Data

Mortality rates were estimated for raised length frequency samples for the period June 2006 – June 2007, assuming equilibrium within the period. The 'length converted catch curve' fitting method, as implemented in the LFDA software was utilised. The length frequencies were raised based on the proportionality of the sample and total catches for each month from June 2006 to June 2007. Length frequency sample sizes per quarter are reported in Table 2.

Table 2: Total length frequency sample sizes by quarter and gear type, as used in estimating king mackerel total mortality rates for the period June 2006-June 2007.

Year	Gear	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 5	Gear Total
June '06 - June '07	A-la-vive	601	207	3	14	59	884
	Banking	0	6	0	0	0	6
	Switchering	6	0	0	0	0	6
	Trolling	35	323	60	28	151	597
	Year Total	642	536	63	42	210	1493

1.8.4.3 Results and Discussion

Total mortality rates based on the low and high $L_{infinity}$ model fits were estimated at 1.46 and 1.71 respectively; substantially greater (by an approximate factor of 3) than the mortality estimate of 0.53 based on the Gulf of Mexico and Florida model (Brooks and Ortiz, 2004) (Table 3). Thus, depending on the growth model used, the estimates of mortality are substantially different to the extent that the level of uncertainty with regard to the model inputs is such that further resolution of the estimates of these parameters is critical.

Table 3: Total mortality rate (Z) estimates for each combined quarter's samples (i.e. Q1 to Q5) for the raised, Jun 2006- Jun 2007 data set, for the different growth model fits, using the length converted catch curve (LCCC) estimation method. The reported means give the averages across the five quarters.

Model fit	Total mortality rate (Z)						SE	Weighted mean
	Q1	Q2	Q3	Q4	Q5	Mean		
Low L_{inf}	1.77	1.62	0.91	1.42	1.35	1.41	0.073	1.46
Med L_{inf}	2.18	1.82	0.94	1.54	1.71	1.64	0.102	1.71
Gulf of Mexico	0.58	0.57	0.39	0.46	0.58	0.52	0.019	0.53

SE = Standard error of the mean of the five quarterly estimates.

1.8.5 Assessment 2

1.8.5.1 Objective - Analytical yield per recruit modelling

F-based reference points, $F_{0.1}$ and $F_{20\%SPR}$, were estimated at the Second Scientific Meeting as a means of determining the status of the stock. The $F_{0.1}$ point shows the level of fishing mortality which achieves close to the maximum yield per recruit, at a low level of fishing effort, and therefore may be considered an 'efficiency' target for the fishery. Additionally, the $F_{20\%SPR}$ reference point is the fishing mortality rate at which the spawning stock biomass per recruit is reduced to 20% of its unfished level. The 20% value is commonly used as a threshold value below which the fishery has a high risk of recruitment failure and stock collapse (Gabriel and

Mace, 1999). Given the stated objective of maintaining the sustainability of the fishery, the $F_{20\%SPR}$ should not be exceeded.

1.8.5.2 Methods/Models/Data

The 2006-2007 estimates of fishing mortality were compared to the reference points ($F_{0.1}$ and $F_{20\%SPR}$) and the 1996-1998 estimates of fishing mortality, for both the 'low' and 'medium' $L_{infinity}$ growth models which were estimated at the Second Scientific Meeting. The 2006-2007 estimate of fishing mortality and the limit reference point $F_{20\%SPR}$ derived from the Gulf of Mexico and Florida growth model (Brooks and Ortiz, 2004) were also compared.

Natural mortality rates were estimated using the Pauly method (as implemented in the 'Yield' software) at 0.51-0.59. These values were subtracted from the estimated Z values to give the reported F values in Table 4.

Also given in Table 4 are the parameter inputs for the periods 1996-1998 and 2006-2007 and the low and medium $L_{infinity}$ growth models.

Table 4: Model parameter inputs used in the 'Yield' analytical fishery modeling for the low and medium $L_{infinity}$ growth models.

Year/s	VBGF model fit	$L_{infinity}$ (cm FL)	K	t_{zero}	Z	M	F
1996-98	Low $L_{infinity}$	129.75	0.35	-0.52	1.26	0.59	0.67
	Medium $L_{infinity}$	154.86	0.30	-0.44	1.70	0.51	1.19
2006-07	Low $L_{infinity}$	129.75	0.35	-0.52	1.46	0.59	0.82
	Medium $L_{infinity}$	154.86	0.30	-0.44	1.71	0.51	1.13
	Gulf of Mexico & Florida	130.00	0.15	-3.60	0.53	0.34	0.18

Notes: Uncertainty in the VBGF parameters set at CV=0.15, SDt_{zero} = 0.5, as estimated for $L_{infinity}$.
For all models: length-weight coefficient a = 0.0087 (CV = 0.2) and b = 2.97 (CV = 0.015); natural mortality rate, M estimated using Pauly equation with K and $L_{inifinity}$ for that model fit and water temperature = 27°C; mean length at maturity = 56.5cm (CV = 0.05); spawning season = October to March.
For 'baseline' models: mean length at first capture = 50cm (CV = 0.05); fishing season = 12 months (i.e. open to fishing all year).
SRR constant CV=0.3

1.8.5.3 Results and Discussion

As occurred in the 2006 assessment with respect to the 1996-1998 estimates of F; the relationship between the 2006-2007 F estimates and the reference point F values varies depending on the model inputs. For the yield per recruit analysis, $F_{06\text{-}07}$ was above the $F_{0.1}$ reference point for both the low and medium $L_{infinity}$ models (two left-hand plots of Figure 1). However, $F_{06\text{-}07}$ was 3 times greater than $F_{0.1}$ for the medium $L_{infinity}$ model and twice as great as $F_{0.1}$ for the low $L_{infinity}$ model. Both results indicate that the fishery is inefficient in terms of the fishing effort employed, but they give differing indications as to the degree of inefficiency.

The spawning stock biomass per recruit analyses (two right-hand plots of Figure 1) suggest substantially different scenarios. The low $L_{infinity}$ model suggests that $F_{06\text{-}07}$ was slightly greater than (almost equal to) the $F_{20\%SPR}$ reference point, and hence the fishery is at a critical point where the mortality must not be allowed to increase. The medium $L_{infinity}$ model, however, suggests that

$F_{06\text{-}07}$ was almost twice as high as the $F_{20\%SPR}$ reference point, and that as indicated in the 2006 assessment, the fishery is at risk of recruitment failure.

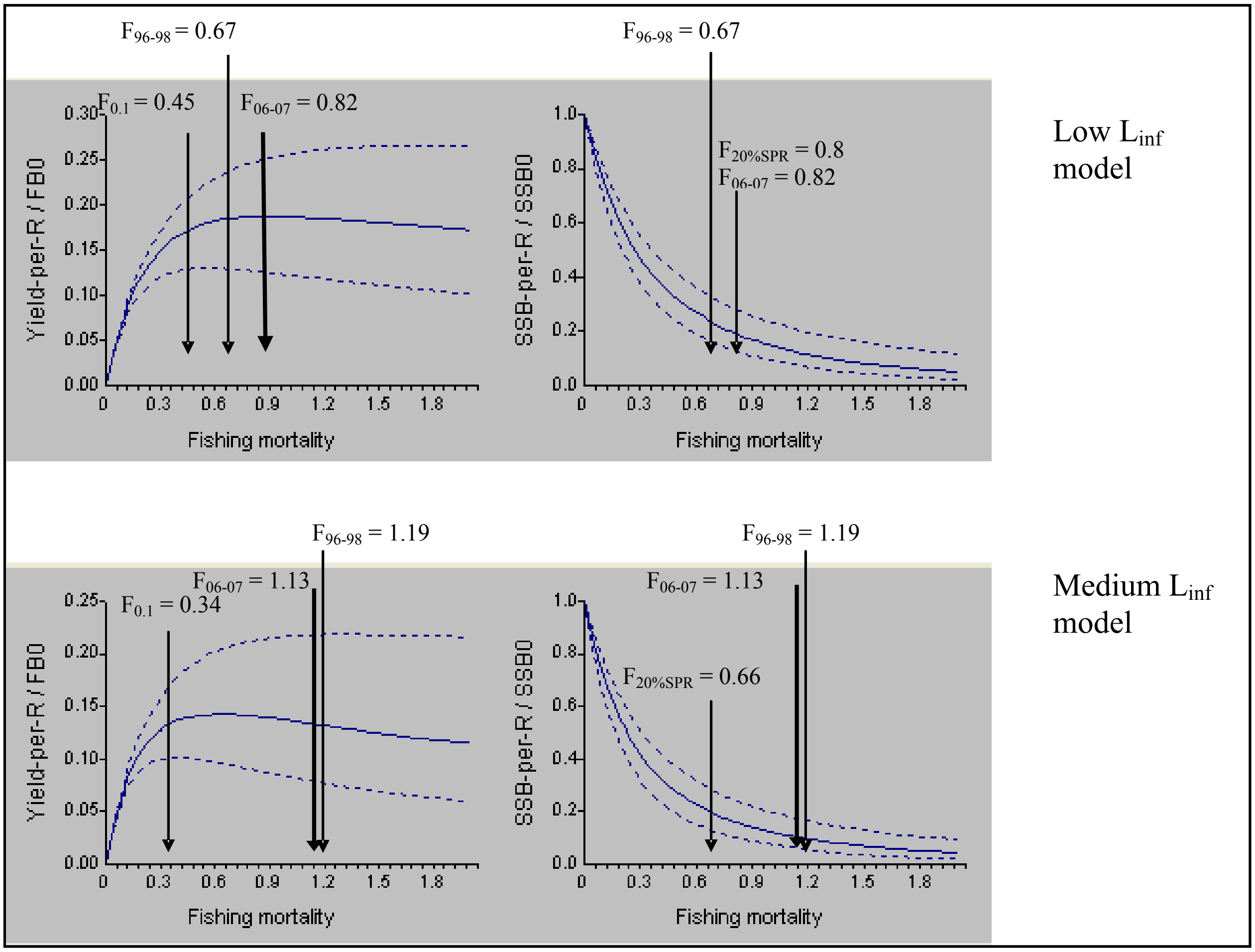

Figure 1: Relative Yield per Recruit (YPR) and Spawning Stock Biomass per Recruit (SSBPR) indicators, plotted against fishing mortality rate for the low and medium $L_{infinity}$ growth models. Arrows show the average fishing mortality rates for the 1996-98 and 2006-2007 data sets estimated using each model fit and the corresponding $F_{0.1}$ and $F_{20\%SPR}$ reference points. Dotted lines show the 95% confidence intervals around the median values at each fishing mortality rate.

The limit reference point, $F_{20\%SPR}$, and the 2006-2007 fishing mortality rate based on the Gulf of Mexico and Florida growth model were estimated at 0.55 and 0.18 respectively, indicating that fishing effort may be increased in the fishery.

The comparison of mortality rates between the 1996-98 period and the 2006-2007 period estimated for any particular set of growth parameters, however, suggests that there has not been a significant change in fishing mortality in the last 10 years. The fact that total catches (as estimated from FAO statistics) have fluctuated without a trend during this period is consistent with a stock that is being harvested sustainably.

The updated stock assessment for king mackerel remains inconclusive. The status of the stock as measured by the target reference point ($F_{0.1}$) and the limit reference point, ($F_{20\%SPR}$) varies greatly depending on the growth/natural mortality parameter combination used in the analysis. Estimated fishing mortality rates were anywhere from well above the limit $F_{20\%SPR}$ reference point (indicating severe overfishing) to below the target reference point of $F_{0.1}$ (indicating there is room for expansion) depending on which of the sets of growth parameters and corresponding natural mortality estimates were used.

It is not known whether the stock is over fished or not, thus the current exploitation level may be sustainable, but may not be at the level desired by management. The status of the stock remains uncertain, however, the possibility that fishing mortality is already above the limit reference point exits, therefore management should be precautionary and invest the necessary resources to reduce the uncertainty in the evaluation of stock status by supporting the research recommendations outlined in this report.

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2.0 Wahoo (*Acanthocybium solandri*) Fishery

2.1. Management objectives

The management objectives for wahoo specifically for most CRFM member countries were again not available to the authors at the time of writing. As a result, the CRFM Large Pelagic Fisheries Working Group requests guidelines from the Caribbean Fisheries Forum on the individual country management objectives for wahoo to direct future stock assessments and further refine management recommendations for the species.

2.2 Status of stocks

It should be noted that unlike the previous stock assessment carried out on wahoo by the CRFM large pelagics working group in 2004, the current update of the stock assessment only utilized landings datasets for the Barbados moses and dayboat fleets and the St. Lucia pirogue fleet for the period 1996-2006. There were a number of rationales for this decision, which will be discussed in section 1.5 No declining trend was observed in the catch rates over the 11-year period considered here (1996-2006) (Figure 1). Based on this observation it may be inferred that the local abundance of the stock is sustainable at these levels of harvest at least in the short term.

2.3 Management advice

The assessments conducted at this workshop cannot be considered extensive enough to predict the long-term sustainability of the fishery at current or increased levels of exploitation. With this in mind a precautionary approach should be adopted in managing and further developing this fishery until the stock dynamics are better understood.

Given the number of nations that are likely to be fishing the wahoo stock within the WECAFC area and the possible interests of some fishing nations to expand their pelagic fisheries, management of the wahoo fishery should be based on collaborative arrangements between the CRFM and major non-CRFM fishing nations in the region. The information obtained on the status of the stocks from these CRFM stock assessments is very valuable. However, collaboration with non-CRFM nations fishing in the area would further enhance the level of knowledge of the stocks and thus the management advice offered. As such collaboration with these non-CRFM fishing nations should be further encouraged. Possible mechanisms for such collaboration or information gathering are outlined in the Chairman’s report for the large pelagic working group.

Although for this year’s assessment the decision was taken to analyze the data from only two CRFM countries, it must be noted that the lack of a fully functional common data management program for member countries will continue to make the prompt sharing of data for collaborative assessments such as these difficult in the future. CRFM should therefore urgently finalize the development of the CARIFIS programme for member countries to facilitate the storage of national data in a common format that would facilitate the merging of national databases for joint stock assessments.
It is therefore recommended that the CRFM:

1. Continues to monitor catch rate trends at a regional level.
2. Further promote and coordinate more extensive stock assessments and management through collaboration with non-CRFM nations fishing this resource.
3. Finalize the CARIFIS programme for collecting fisheries catch and effort data and facilitate the use of the programme by CRFM member countries.
4. Encourage countries to individually track catch rate trends of the fishery to allow early detection of any changes that may signal stock decline.

5. In the event that catches or catch rates decline, facilitate prompt collaboration among countries to achieve consensus on the appropriate management strategies to be adopted.

2.4 Statistics and research recommendations

Following are a number of recommendations to be addressed by the CRFM and individual countries for improvement of the quality of future assessments. It should be noted that all have not been introduced in the text so far and most have been recommended in the wahoo assessment report of 2004:

2.4.1 Data Quality

Recommendations for the Caribbean Regional Fisheries Mechanism

1. Review systems (e.g. logbook and or observer based programs) for recording more refined estimates of fishing effort among countries particularly in quantifying unsuccessful fishing trips.
2. Renew and intensify efforts in finalizing CARIFIS for practical use by CRFM member countries.
3. Encourage and assist countries with development of a regional database on historical catches and fishing effort, extending to a time period prior to the commencement of the CARICOM Fisheries Resource Assessment and Management Programme. This exercise will involve intensive data mining from scientific, historical and administrative documents (published and grey literature) designed to expand the time series of available data and glean other information that can be utilized in other assessment models.

Individual countries

1. Countries must ensure that appropriate systems are in place to capture, record and report at least representative landings data for wahoo.
2. Provide accurate and complete data on total catches (or landings) of wahoo in the format and level of detail required by the CRFM for incorporation into stock assessments.
3. Provide more detailed information on fishing effort associated with each catch record e.g. boat/ gear type and number of gear units as well as number of hours fishing or the number of hooks used. This information can facilitate improved estimates of catch per unit of effort and fish abundance.

2.4.2 Research

Recommendations for the Caribbean Regional Fisheries Mechanism

1. Monitor trends in regional catches and catch rates to identify signs of stock decline and promote regional collaboration on appropriate management strategies to be implemented.
2. Continue to encourage participation and further collaboration of non-CRFM territories in the WECAFC region e.g., USA, Venezuela and the French territories in future stock assessments.
3. Implement a tagging programme for wahoo to collect the range of information for this species that such studies can generate, such as migration patterns and ranges.
4. Formally work with the IMA in conducting otolith based ageing of wahoo aimed at providing information on the age structure of catches and refined estimates of growth parameters for future assessments.

Individual countries

1. Future analyses should take into account ‘zero’ catch trips to improve estimates of total fishing effort. Where necessary, revisions to sampling strategies should be considered to improve estimates of fishing effort and fish abundance.

2. Conduct extensive review of historical data (data mining) aimed at providing information on historical catch rates and catches to improve fitting of model parameters in future assessments.
3. Submit fleet information to CRFM outlining on-going and historical developments to allow elucidation of the effects of changes in the fleet, fishing methods and technology on catch rates.
4. Implement programs to collect fleet and landings information for recreational fisheries this would include but be confined to data on fishing tournaments.
5. Work with CRFM/IMA to develop and implement periodic sampling programmes to collect and provide specimens as required for use in assessments to track growth parameters and age structure of the wahoo stock.

2.5 Stock assessment summary

As mentioned earlier, only the landings datasets for the Barbados moses and dayboat fleets and St. Lucia pirogue fleets were used in this year's update of the stock assessment analysis. The rationales for this decision are as follows:

- The Barbados and St. Lucia datasets were the most complete national historic datasets available to the meeting in terms of the fewest missing years of data.
- St. Lucia contributes the largest proportion of wahoo captured amongst the CRFM member countries (48% based on mean annual catches reported to FAO for the period 1990-2004 that presently report wahoo catches to FAO (7) and therefore should be the most significant driver of any regional catch trends.
- Barbados iceboats and longliners typically fish for a number of days (not recorded) and as such their fishing effort is not comparable to the vessels that typically have fishing trips of less than 1 day in duration. Therefore to reduce burdening the models with having to adjust for these differences the iceboat and longline vessels were not included in the assessment.
- By the same token, longline gear would have a much higher potential fishing power than the troll and handline gears used on the other fishing vessels to capture wahoo.
- In the end therefore, only catches taken by single-hook handline and trolling gear used by vessels of more similar fishing power were used.

As no additional information was collected during the inter-sessional period which would facilitate any other in-depth analyses, it was decided that a simple comparison of catch rates (standardized catch per trip) over the period would be the most informative analytical tool. The Univariate Multifactor ANOVA of the SPSS program was used to standardize the log cpue data with respect to the key factors identified (vessel type, season and year). Two seasons were defined based on relative aggregated catch weights during months for all years of the study period and were categorized as follows: high (January to May) and low (June to December).

It must be noted that present records for wahoo landings available for this assessment are necessarily positive catches and at present there is no means of quantifying the numbers of times that a fisher attempts to catch wahoo without success. The numbers of these unsuccessful or zero catches at any point in time are obviously important indicators of fishing abundance and should be taken into account when utilizing temporal catch rate trends as relative indices of stock abundance.

In this study an attempt was made to estimate zero catches by counting the numbers of catch records for pelagic species other than wahoo (*viz* dolphinfish, tunas, billfishes and swordfish) taken by Barbadian vessels using handline and trolling gears. However, the number of observations of zero wahoo catch was relatively greater in the "high" season than in the low season. This is markedly counter to the expected trend. This result may be an artifact arising from the procedure used to define a zero wahoo catch. As such a trend may confound the interpretation of the results from this method of estimating zero wahoo catches this data was not used.

The best methods for estimating zero catches rely on country reporting of fishing activities whether through interviewing fishers, monitoring vessel activities at the landing sites (i.e. noting if a vessel has gone fishing and subsequently determining if wahoo was caught) or the use of catch logbooks.

2.6 Special comments

None.

2.7 Policy Summary

The working group requires more information and guidance from the CRFM Fisheries Forum on regional policies for wahoo.

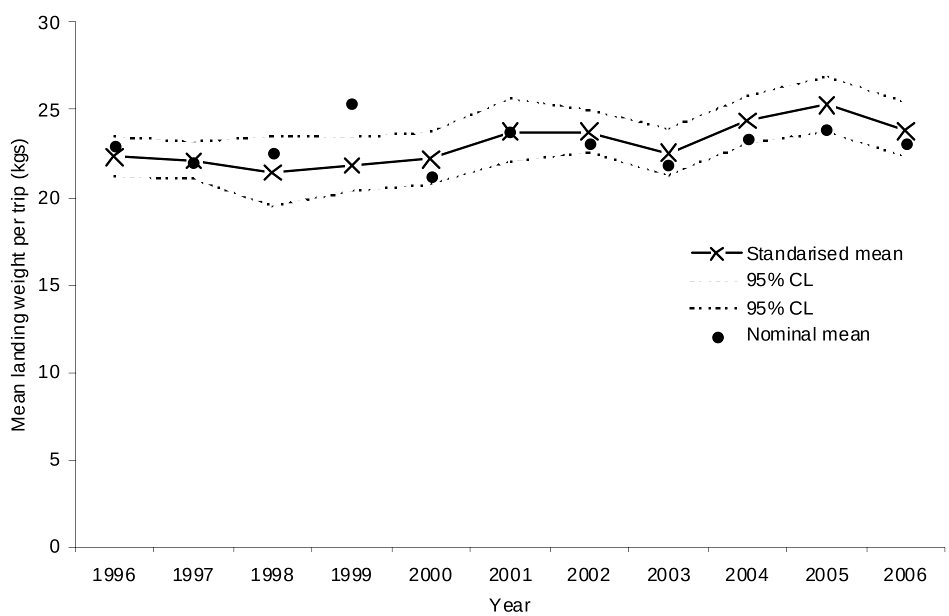

Figure 1: Standardized catch rates for Barbados moses and dayboats and St. Lucia pirogues for the period 1996 to 2007

2.8 Scientific Assessments

2.8.1 Background

Oxenford *et al*. (2003) gives a detailed account of the biology of wahoo and the following sections on the species biology, distribution, migration patterns and stock structure have largely been extracted from this work.

<u>2.8.1.1 Biology</u>

Wahoo (*Acanthocybium solandri*) is a large, fast-growing, oceanodromous pelagic fish. Estimates of the species longevity range from between five and six years (Oxenford *et al*, 2003) to as much as ten years according to Kishore and Chin (2001). In the WCA region, Wahoo reach sexual maturity within the first year of life and the species exhibits an extended spawning season from May to October (Hogarth, 1976). The species exhibits high fecundity (Brown-Peterson *et al*., 2000). Wahoo are piscivorous, feeding mainly on scombrids, exocoetids, clupeids, cephalopods, and to a lesser extent species associated with floating material.

2.8.1.2 Distribution, Migration and Stock Structure

Wahoo is widely distributed in both tropical and sub-tropical seas, seasonally extending into temperate waters. In the WCA region the species is found as far north as New Jersey to the Northern coast of South America and throughout the Gulf of Mexico to Venezuela (Robins *et al*., 1986). Based on the limited evidence available, for the purposes of management, the SAFMC (1998, 2000) adopted the model of a single WCA-wide Wahoo stock. Subsequent genetic studies (*e.g.* Constantine, 2002) support this single-stock hypothesis, and Constantine (2002) even suggests that the stock boundaries may extend beyond the WCA.

Little is known of the migration patterns of Wahoo within its range. It is believed that in the northern part of the WCA, Wahoo migrate through the Florida Straits along the Gulf Stream during the early spring with peak migration in late July and early August (Rivas, 1951). Neilson *et a*l. (1999) suggests that there is year-round recruitment to the fishing grounds in the eastern Caribbean with highly migratory behaviour out of the area at larger sizes. Nielson *et al*. (1999) proposed that the fish followed a similar pattern for the postulated southern dolphinfish (*Coryphaena hippurus*) stock (cf. Oxenford and Hunte, 1986) *viz*. sequential northern movement through the Lesser Antilles with a return migration south via waters further to the east.

George *et al* (2001) found an initial steady increase in mean lengths of Wahoo landed in 5 islands in the eastern Caribbean from October to July followed by a sharp decrease in mean lengths from July to August. The relationship of fish length and month essentially reflected the relationship of catch weight and months and as such the authors postulated that the pattern was caused either by the absence of larger fish during the latter part of the season possibly due to migration beyond the Eastern Caribbean or increased abundance of smaller individuals during the period. In addition, George *et al* (2001) observed a general decrease (in a south to north direction) in the mean lengths of Wahoo samples caught in the five sampled islands. Subsequently, Parker *et al* (2005) in their assessment of the eastern Caribbean datasets (including the length frequency dataset used by George et al, 2001), noted that Wahoo taken by rod and reel gear in waters surrounding the eastern Caribbean (Gulf of Mexico, Northern Caribbean and Atlantic USA) were larger (mean 100 cm FL, many over 120 cm FL) than the fish landed within the Eastern Caribbean (mean of around 90cm FL, few over 120cm FL). The relative dearth of these larger animals in the eastern Caribbean area compared with adjacent waters added further credence to the emigration of fish out of the eastern Caribbean area before they reached very large body sizes. The authors also noted that relatively small Wahoo (<70 cm FL) were only found in the significant numbers in samples from the most northern of the islands assessed (viz. St. Lucia and Dominica). Based on this observation Wahoo recruits may migrate into the waters of these northern islands however there seems to be little evidence to support an overall south-north migration pattern through the Caribbean for the stock *per se*.

2.8.1.3 The fishery

Although not targeted *per se*, Wahoo (*Acanthocybium solandri*) is an important species landed in the commercial pelagic fisheries of the Eastern Caribbean. Individuals are more often solitary or may form small loose aggregations rather than more stable schools. This non-gregarious way of life may be a major stumbling block for fishers organizing a significant directed fishery for this commercially valuable species. In the Eastern Caribbean, large pelagics are taken by a variety of gears ranging from single hook and line to horizontal longlines. Vessels participating in the large pelagic fisheries also range in sophistication from simple open pirogues and Barbadian “moses” to custom built or converted decked longline vessels. Most of the fishing for large pelagics takes place along the eastern side of the Windward Islands, to the south and west of Barbados and off the north and northeast coasts of Trinidad and Tobago. Wahoo are generally believed to be present in the area year round although abundance appears to vary with season. Highest catches of wahoo occur between January and May and lowest catches occurring from June to September (Hunte, 1987). The species is also taken in the recreational fisheries of several eastern Caribbean islands and is a target species in some fishing tournaments. George *et al*., 2001 (quoted by Parker et al., 2004) provide a detailed description of the Wahoo fishery in the Eastern Caribbean and Oxenford *et al*. (2003) provide additional information on fisheries throughout the distribution range of the species within the Atlantic.

2.8.1.4 Fisheries Management

None of southeastern Caribbean countries have any active management regulations pertaining directly to Wahoo. Statistics on Wahoo are reported to and collated by ICCAT, but no stock assessments have been carried out or any specific international regulations proposed.

In the US, the South Atlantic Fishery Management Council in collaboration with the Mid-Atlantic and New England Fishery Management Councils developed a comprehensive fishery management plan for both Dolphin and Wahoo in the Atlantic which went into full effect from by December 2004. The US Wahoo fishery is now subject to: Gear restrictions (only hook and line and spear fishing gear may be used); longline gear may not be used to take the animals in areas where use of that gear is prohibited for highly migratory species; owners, dealers and operators of charter boats, head-boats and commercial vessels must have permits and may be required to submit reports on there activities; longline vessels must comply with sea turtle protection measures and catches are limited to 500lbs of Wahoo per trip and 200lbs of dolphin and Wahoo combined for commercial vessels fishing North of 39 °N latitude without a Federal commercial vessel permit.

2.8.1.5 Summary of previous stock assessment work

In George *et al.*, (2001), the Wahoo stock assessment was largely based on a length-based approach, which included the following methodologies:

Growth rates estimated from Modal Progression Analysis followed by Linking of Means in 'FiSAT' (Linf = 203.5cm, K = 0.47 y-1).
Total mortality rates (Z) estimated from length-converted catch curves for 1996 (5.41 y-1) and 1997 (4.58 y-1).
Natural mortality rate (M) estimated using Pauly equation (0.63 y-1).
Length at first capture (selectivity) from the catch curve method (Lc = 90.4cm).
MSY = 2 137 t and FMSY = 0.34 y-1 estimated from the Thompson and Bell predictive length based model.
Target harvesting rates estimated from length based Thomson and Bell YPR model (F_{max} = 1.09 y-1 and F0.1 = 0.37 y-1; F30%SPR = 0.68 y-1 and F40%SPR = 0.47 y-1).

Based on the fishing mortality rates estimated tentatively as F = Z-M = 3.98 y-1, George *et al* (2001) concluded that the fishery was overexploited and that current F levels were not sustainable.

The assessment of Parker *et al*, 2005, also examined available length frequency data to determine their potential value to the Wahoo stock assessment and to search for evidence of migration patterns around the Caribbean region. The 'LFDA' software (published by MRAG Ltd and downloadable from the DFID Fisheries Science Management Programme website -

http://www.fmsp.org.uk/) was used to assess the growth of fish over time by plotting the time-series of length frequencies.

However, the available Wahoo length frequency data was interpreted as having limited value for stock assessment. While some samples in the southeast Caribbean (viz. Dominica and St Lucia) had a number of small fish (30 to 70 cm, FL) in the 3rd and 4th quarters of the year, assumed to be the entry of new year-classes, most samples of Wahoo throughout the region were medium-sized fish (70-100cm). Yet, while fish above 100cm were uncommon in the eastern Caribbean, they were reported in rod and reel samples provided by ICCAT for the Gulf of Mexico and northern Caribbean/eastern US waters. Therefore, the dearth of large fish in the eastern Caribbean length frequency data was interpreted as the result of emigration out of the southeastern Caribbean area rather than mortality assumed by George *et al,* 2001 for their mortality estimates.

Catch rate data (CPUE) from the fisheries were also examined to provide a relative index of the abundance the stock. A GLM procedure was used to standardize records of individual landings of wahoo by 4 defined vessel types (dayboats, pirogues (including Barbados Moses), iceboats and longliners) from 5 islands (Barbados, Dominica, Grenada, St. Lucia and St. Vincent) covering the 10-year period from 1994 to 2003, inclusive. Vessel type, island, month and year were the four main effects identified and used in the model and all were found to have significant effects on it. The final model used included all second order interactions except for country by month as that interaction contributed little to the R^2 of the model. The final standardized plot of mean annual catch rates in the region over the time period did not show any obvious pattern and certainly no downward trend.

Parker *et al*. 2005 also attempted Biomass dynamic (surplus production) modeling to estimate the maximum sustainable yield (MSY) reference point for the fishery, and to investigate the relationships between the annual catch rates, the total catches removed from the fishery and the likely changes in stock sizes over time. For this the standardized mean regional annual catch rates obtained were used. However, due to the short time series, the analysis was unable to accurately predict the model parameters (K, r and q) and MSY could only be estimated approximately as the peak catches taken in 1997-1999 (i.e. 1400-1600 t). However, recent catches were assumed to be sustainable since catch rates had not declined at these levels of harvest.

2.8.2 Objective

The overall objective of these analyses was to ascertain the current status of the Wahoo stock and to advise on the future management of Wahoo fisheries in the Eastern Caribbean area. Standardized catch rates (CPUE) were examined to provide an index of the abundance of the fish stock in recent years.

2.8.3 Method/models/data

Previous assessments of the Eastern Caribbean catch dataset (George *et al,* 2001; Parker *et al*, 2005) tracked temporal catch trends utilizing data for all countries and vessel types represented in the dataset. For these assessments, conventional General Linear Model (GLM) procedures were used to standardize the data. However as noted by the authors, the datasets used included some significant data gaps such as some entire years of missing data for some islands. While the GLM procedure is considered to be robust enough to handle uneven factor sample sizes, the inclusion of missing data blocks of key factors (catches for an entire year) would seem to inherently potentially introduce some biases to the model. This would be even more pertinent since the primary dependent parameter being considered is annual catch rate through time. Another potential bias is mired in the use of catch per trip as the unit of catch per unit effort for vessels such as iceboats and longliners that can stay at sea for significantly different time periods (numbers of days). While it is appreciated that these vessels contribute significantly to the region's total catch of this species, without the information on the length of time spent fishing during each trip, it is impossible to make the necessary adjustments that would realistically facilitate good temporal comparisons of CPUE. For these two reasons the present assessment focused entirely on the landings data for two islands (Barbados and St. Lucia) that had the most complete annual datasets covering the longest time period (1996-2006) and was restricted to vessels types (*viz.* Barbados Moses and dayboats and St. Lucia pirogues) that had more comparable fishing power and trip lengths (within 1 day).

The catch data was natural log transformed and a box plot used to identify outlier data. These data were individually examined and excluded from the subsequent data analyses if deemed to be either unrealistically high or low. After these treatments a total of 16784 landing records were analysed.

The General Linear Model (GLM) approach was taken to standardize the natural log transformed catch data. In addition to the main independent variable of interest viz. year month, three other possible influencing factors were identified for possible inclusion as independent variables in the model viz. month, vessel type and island. In addition to the variable "year" the partial eta squared (□□) statistic was used to determine the relative effect of each of the other parameters on the model and thus the need to include them after sequentially adding one at a time and running the GLM procedure (see statistics in the results section). To avoid over-parameterization, the final model was restricted to including only year and month and the interaction parameter (year*month).

2.8.4 Results and Discussion

The partial η^2 statistics for the parameters and interactions tested for inclusion in the model are presented in table 1. The partial η^2 values for all the parameters were very modest by conventional standards (all < .04). However, month and the interaction variable year*month had larger partial η^2 statistics by comparison with the η^2 statistics for both vessel type and island.

Table 2: Statistics for GLM models tested in the present study (Ln catch per trip was the dependent variable in all cases.

Independent variable	Model R^2	**Model Adjusted R^2**	Partial η^2 values for independent variables in model
Year Month	.037	.036	.001 .035
Year Month Island	.044	.043	.001 .032 .008
Year Month Vessel type	.047	.045	.001 .033 .010
Year Month Year*Month	.065	.058	.002 .028 .029

These results indicate that month exerts a reasonable impact on the model, which is not surprising as there is marked seasonality in catch rates. Furthermore the interaction between month and year indicates that there are some inter-annual differences in monthly catch rates between years. The plot of total monthly-recorded landings by month over the study period (Figure 2) illustrates both these points. The plot indicates that the inter-annual pattern of landings was very similar across the years with peaks always occurring in the first half of the year yet relatively, and arguably anomalously, high landings of Wahoo were also made during the latter half of some years, most notably 2000.

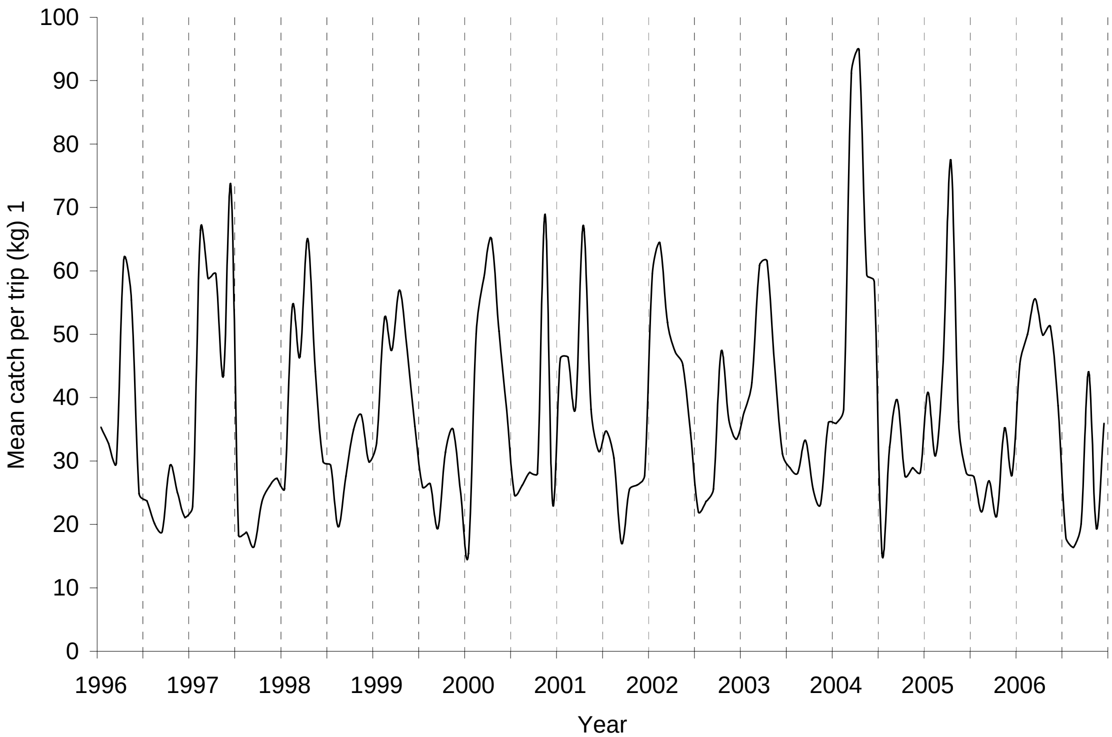

Figure 2: Seasonality of Wahoo catches illustrated by mean recorded landings per trip for Barbados Moses and Dayboat fleets and St. Lucia pirogue fleet for the period 1996-2006. Vertical dotted lines delimit 6-month intervals

These results suggest that catch rate (catch per trip) was affected relatively little by fishing location (*viz.* off St. Lucia or Barbados) or by the type of fishing vessel. Considering that compared to the presumed wide geographic range of this species (the Western Central Atlantic) it is not surprising that the abundance of the species would differ little across the combined fishing ranges of the vessels fishing from the neighbouring islands of Barbados and St. Lucia. The lack of impact of vessel type supports the assumption that these vessels are all relatively equal in terms of fishing power and thus catch success for this species.

A fairly level trend was observed in both the nominal and standardized catch rates over the 11-year period considered here (1996-2006) (Figure 1). As such assuming the catch per trip of the vessels analyzed here is a valid index of abundance, it may be inferred that the local abundance of the stock is sustainable at these levels of harvest at least in the short term.

However, it remains disconcerting that the stock assessments have hitherto been constrained to the statistics that do not include the number of large pelagic fishing trips during which Wahoo were not caught. The number of these “zero catch trips” is probably particularly important for a species such as Wahoo in which individuals are mainly non-gregarious and largely only caught incidentally in the first place. Note that for the vessels assessed in this study, the standardized annual mean catch per trip was only 21 kg, which for this species translates to about 3 individuals. Given the very low magnitude of this mean value it would seem that there is a high probability of not catching any Wahoo on a given trip thus emphasizing the importance of the ratio of unsuccessful trips to successful trips as a relative index of abundance for the species. It is somewhat reassuring that the previous analysis of the broader regional data (Parker *et al* (2004) also found a stable trend in catches given that those analyses not included landings statistics from a larger geographic range (viz. also from Grenada to St. Lucia) and for the iceboat and longline fleets which by virtue of engaging in multi-day fishing trips are more likely to land Wahoo in any given trip and as such would be included in the statistics analyzed. Nevertheless, the caveat must be reiterated that without info on the length of the fishing trips of the iceboat and longline vessels, the corresponding landings data cannot be viewed as cogent catch per unit effort data *per se*.

It must be noted that the southeastern Caribbean represents only a small portion of the presumed geographic range of this species and the contribution to total catches are presumably concomitantly relatively small. This point is however not often well reflected in international fish landing statistics databases largely because of the non-reporting or inconsistent reporting of landings by other significant fishing entities operating in the region. For example, the FAO landings database (FISAT) indicates that Barbados and St. Lucia landed around and annual mean of 25% of the wahoo catches from the WECAFC region over the period 1996 to 2004 (inclusive) and the five islands thus far contributing to the CRFM regional wahoo database (*viz.* Barbados, Dominica, Grenada, St. Lucia and St. Vincent) landings accounted for 40% of the FAO recorded landings for the species over the same time span. However, it is only for 2004 that landings by the Spanish fleet operating in the area, accounting for 25% of the year's total regional harvest in that year, were listed in the database. Such uncertainties in the true level of harvest in the region make it almost impossible to offer any informed opinions on the status of the stock. Certainly extrapolating the inferences made from analysis of landings data from such a small portion of the animal's range by largely artisanal fleets to the wider stock must be done with a great deal of caution. In this regard it must be emphasized that the participation of more fishing entities in the region in further assessments of the status WECAFC Wahoo stock is needed for informing management of this trans-boundary species.

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Appendix 7: The CRFM Fisheries Tagging Programme

1.0 EXECUTIVE SUMMARY

Given that many commercial fishery resources within the Caribbean region are believed to be shared among two or more territories, quantifying the nature and extent of resource sharing will provide essential information to support the required co-operation in fisheries management among the parties concerned. In addition, effective application of and support for several management tools such as marine reserves, closed areas and closed seasons, require quantifiable evidence of both small-scale and large-scale resource movement patterns throughout the life history, including information on settlement patterns, habitat preferences, as well as feeding and spawning migrations.

Given the importance of these fisheries resources to the region, a CRFM Fisheries Tagging Programme would facilitate: CRFM technical and financial assistance to countries for implementation of priority tagging research identified by individual countries or by the CRFM scientific meetings; and development of a central tagging data and information database. The information gained from analyses of data gathered would be used to inform the development of policies and institutional frameworks, and to enhance fisheries management and development throughout the CRFM region. By this means, a CRFM Fisheries Tagging Programme would therefore provide the necessary record over time of the CRFM's contribution to fisheries management through tagging research studies, and hence also accountability in respect of the fulfilment of this part of the CRFM's mandate as a regional indigenous organization.

It is anticipated that specific projects planned and implemented under the CRFM Fisheries Tagging Programme make use of available donor funding. In 2007-08, work can commence on the design of the tagging database, using resources currently available to the Secretariat.

2.0 INTRODUCTION

Historically, the production and consumption of fish and other aquatic organisms have been important to the economic and social well-being of many developing countries (Saila and Gallucci, 1996). This is particularly so, for Caribbean countries, especially the small island states, which depend heavily on their marine resources for economic and social development (Haughton,2004), During the period from 1950 to 1970, global fish harvests increased rapidly with an annual growth rate of approximately 6% (Hilborn *et al.*, 1990). This rapid increase was a result of improved gear, technology and expanded fishing grounds (Saila and Gallucci, 1996). However, after 1970 there has been less than 1% growth in annual fish landings (Hilborn *et al.*, 1990; Saila and Galluci, 1996). In 2002, the global production from capture fisheries and aquaculture accounted for approximately 101 million MT of food fish with the average per capita supply being 16.2 kg; however aquaculture has been responsible for the per capita growth since 2000 (FAO, 2004b). The available statistics for the Caribbean ACP States, indicate that there has been constant growth in fish production from the 1950s, and in 2000, the annual nominal production of fish was 195 000 MT, with an approximate value of 700 million USD, and a per capita consumption between 23-25 kg (Haughton, 2004). The removal of trade preference agreements for agricultural products by the WTO has also led to increased numbers of new fishers and investors in the fisheries sector (Haughton, 2004). In some CARIFORUM States, fisheries can account for up to 8 % of the GDP, with the real contribution being much higher since fish processing and distribution statistics are not incorporated into the GDP calculations (Haughton, 2004).

In fishery resource management, the optimum sustainable yield concept has been developed to provide a solution to the problem of overfishing (Saila and Gallucci, 1996). It has been estimated by FAO that by optimising yields, 20-30 million tonnes could be added to the world catch (Saila and Gallucci, 1996). In the case of small-scale tropical fisheries, data are limited; however it is reasonable to assume that with better management policies, sustainable yields could be achieved. The optimum sustainable yield of a fishery is determined by carrying out a stock assessment. Tagging or marking fish with ID tags or marks is an important tool used in stock assessments in which fish are caught, tagged, released back into the environment (Thorsteinsson, 2002) and then re-captured. Tags are defined as man made objects attached to a fish, whereas marks are defined as identifiable characteristics, either applied or natural, to a fish (Thorsteinsson, 2002). Hilborn *et al.*, 1990, suggested that fish marking provides useful data for critical management decisions designed to: 1) manage overexploited fish stocks, 2) rationalize the economical aspect of management activities, in order to encourage governments to address the problems associated with reduced fishing opportunities, 3) assist with decisions to eliminate and avoid inefficient programs, 4) provide estimation of fish migration in transboundary stocks, and 5) determine the success of artificial enhancement efforts. Fish marking, facilitates the development of these critical management decisions by providing data on: contribution of the stock to the fishery, fish growth, fish movement, fish survival, rate of exploitation (and thus fishing mortality) and population estimation. In cases where the fishery is dependent on fish from multiple fish stocks, which are highly migratory, fish marking provides a solution in determining the origin of these fish; and release and recapture location data also provide unequivocal evidence of the extent of fish movement as well as sharing. Fish marking allows growth analyses and age validation as well, since the amount of growth that occurred between the times of tagging and re-capture can be determined. Mark and recapture estimates are very useful in estimating fishing and natural mortality rates (Hoenig *et al.* 1998a, b). Tagging studies can also be used to assess the effectiveness of marine protected areas (Lambert *et al.,* 2006).

3.0 RATIONALE FOR ESTABLISHING A CRFM FISHERIES TAGGING PROGRAMME

The fisheries sector is very important to the CRFM region, as it generates over 150 million USD in foreign exchange annually, and employs 182 000 persons either directly or indirectly (Haughton, 2004). In terms of nutrition, fish is a major source of protein and minerals, especially for underprivileged members of society (Haughton, 2004). The fisheries sector is also extremely important to food security since most of the fisheries are small-scale, and involve rural fishers (Chakalall and Cochrane, 2004). The sport fishing charter industry and fishing tournaments also complement the region’s economy through their direct linkage to the tourism industry. Fish exports, from the Caribbean region have steadily increased in value from 13.8 million USD in 1986 to 150 million USD in 2000 (Haughton, 2004).

The marine capture components of the fisheries sector within the CRFM region include: shrimp, groundfish, queen conch, lobster, reef fishes, deep slope and bank fishes, coastal and offshore pelagics. The high-value species such as shrimp, spiny lobster, queen conch, tunas, deep-water snappers and groupers are also the main export items (Haughton, 2004). Many of these species are shared by two or more countries and are exploited by CRFM and non-CRFM countries. Consequently, to ensure sustainable use of these resources, regional/sub-regional and bilateral collaborations in research and management are required (CARICOM Fisheries Unit, 2002) and sound scientific information is necessary to facilitate and inform these collaborations. Given the importance of these fisheries resources to the region, it is proposed that a CRFM Fisheries Tagging Programme be established that would facilitate: regional support for development of specific tagging study proposals identified by countries and by the CRFM Scientific Meetings; development of a central tagging data and information database and assistance to countries in analyzing tagging data and formulating scientific advice for managers. The information gained from analyses of data gathered would be used to inform the development of policies and institutional frameworks, and to enhance fisheries management and development throughout the CRFM region. By this means, a CRFM Fisheries Tagging Programme would therefore provide the necessary record over time of the CRFM's contribution to fisheries management in the area of tagging research, and hence also accountability in respect of the fulfilment of this part of the CRFM's mandate as a regional indigenous organization. It is anticipated that the activities planned and implemented under the CRFM Regional Tagging Programme make use of available donor funding.

4.0 FISHERY RESOURCES TO BE INCLUDED IN THE PROGRAMME

4.1 Reef and Slope Fish Resources

4.1.1 Introduction

Reef fish resources refer to those resources which spend most of their lives on island shelves, whereas deep slope fish resources refer to those which spend most of their lives on the deep slopes and submerged banks that occur further offshore (CRFM, 2003). In CRFM countries, the targeted fish families include: Acanthuridae, Balistidae, Haemulidae, Holocentridae, Lutjanidae, Scaridae and Serranidae. At present, it is believed that several of the reef fish resources within CRFM States are fully or over-exploited based on changes in catch species composition, decreased mean fish size and decreased abundance (FAO, 2002). Given the close proximity of some islands to each other, it is possible that neighbouring islands sharing a common shelf may also be sharing the same reef and slope fish stocks; so although the reef and slope fish resources do not undergo large-scale movements, collaboration among the CRFM States is warranted for management purposes (CRFM, 2003). Within the region, there are some dated studies on the movements of reef fish (e.g. Moe, 1966 and Moe, 1967); however, to the best of our knowledge, there have been no tagging studies within the region for the slope fish resources.

4.1.2 Potential Aims and Outputs

In order to ensure the sustainable utilization of the reef and slope fish resources it is necessary to improve the knowledge and understanding of the biology and ecology of these resources (CRFM, 2002). Tagging studies on reef and slope fishes have the potential to provide information on the growth and mortality rates of these resources. It would also facilitate the validation of any age studies that provide input data for a stock assessment. In those cases where islands are sharing a common shelf, tagging studies would also provide information on fish movement and migration patterns. The effectiveness of marine reserves in protecting reef and slope fish resources and in supplying recruits to adjacent fishing areas could be more quantitatively evaluated through tagging research.

4.2 Small Coastal Pelagic Fish Resources

4.2.1 Introduction

Small coastal pelagic catches are composed of species from a range of families, including: Atherinidae, Carangidae, Clupeidae, Engraulidae, Exocoetidae, Hermiramphidae, small tuna species and the young of large tunas (Scomberidae). In some instances, these resources account for up to 40 % and more of the national reported fish landings (e.g. Wilkins and Barrett, 1996, Guiste, 1996, and Ryan, 1996 as cited by CRFM, 2003). These resources also support important bait fisheries in some countries (Kelly, 1996 and Mohammed, 1996 as cited by CRFM, 2003). However, management of the small coastal pelagic fisheries is limited due to the lack of data and information, which are necessary for quantitative assessments (Nakashima, 1996 as cited by CRFM, 2003). The movement and distribution of stocks of small coastal pelagic resources within the Caribbean are not well understood; however it is likely that islands that share a common shelf may be fishing the same stocks (CRFM, 2003). Due to the social and economic importance of the small coastal pelagic fish resources to many Caribbean states, it is very important to improve the knowledge and understanding of the biology and ecology of these resources (CRFM, 2003), their status and their management.

In the region, tagging has been used to validate ageing studies and to investigate movement patterns for the commercially important four-wing flyingfish, *Hirundichthys affini*s, (Oxenford *et al.*, 1993).

4.2.2 Potential Aims and Outputs

Tagging research on small coastal pelagic fishes would be able to provide information on the growth and mortality rates of these resources. It would also facilitate the validation of any age studies that provide data inputs for a stock assessment. In those instances where islands share a common shelf, tagging studies would be able to provide information on the movement and migrations patterns of these resources.

4.3 Large Pelagic Fish Resources

4.3.1 Introduction

Large pelagic fisheries are important to the artisanal, industrial and recreational fisheries in CRFM countries, although the full use of these resources by CRFM countries is yet to be realized. Within the region, therefore, these resources are seen to hold a lot of potential for growth and development (CRFM, 2003). In those fisheries that have been established, the large pelagic fish catches comprise a range of species, mainly from the following families: Scombridae, Coryphaenidae, Istophioridae, Xiphiidae and several species from the class, Elasmobranchii. The large pelagic fish stocks within the region can be considered as two separate groups for management purposes: 1) large coastal pelagics, including wahoo, blackfin tuna and mackerel species, *Scomberomorus* spp; and 2) more widely distributed oceanic species, such as yellowfin tuna, skipjack tuna, swordfish, billfish and others (Chakalall and Cochrane, 2004). These fish stocks are all highly migratory. However, the large coastal pelagics are believed to have more coastal and regional distributions, and could therefore be managed by a suitable regional or sub-regional arrangement (ICCAT, 2005).

Tagging experiments have successfully been used to investigate large pelagic fish movement patterns (e.g. Oxenford, 1986a; Oxenford 1986b; Hampton, 1991; Bayley and Prince, 1992; Ortiz, 2001) and other population parameters such as growth, fishing and natural mortality and population size (e.g. Hilborn *et al.,*1990*;* Parrack and Phares, 1979; Farber, 1988; Porch, 1999; Ortiz *et al.,* 2003). A Large Pelagic Fish Tagging Programme was implemented by CFRAMP, in which, *Thunnus atlanticus* (blackfin tuna), *Acanthocybium solandri* (wahoo), *Coryphaena hippurus* (dolphinfish) and *Scomberomorus cavalla* (king mackerel) were tagged and released at selected locations within the Eastern Caribbean (Singh-Renton and Renton, in press). However, further studies are required for the conclusive determination of the growth, distribution and movement patterns of these species (Singh-Renton and Renton, in press).

4.3.2 Potential Aims and Outputs

Tagging research on the large coastal pelagic fishes would be able to provide information on the growth and mortality rates of these resources. It would also facilitate the validation of any age studies that take place as part of a stock assessment. Tagging studies would also be able to provide irrefutable evidence on the movement and migration patterns of these stocks, as well as the extent of sharing among fisheries.

4.4 Conch and Lobster Resources

4.4.1 Introduction

The spiny lobster and queen conch fisheries are extremely valuable to many CRFM countries. The importance of these fisheries is due to export earnings, income from local sales, consumption, especially within the tourism sector, social and cultural factors and the employment opportunities generated (CRFM, 2004). During the last 30 years, the fishing effort directed at spiny lobster and queen conch has steadily increased (CRFM, 2004). The landings of spiny lobster have remained relatively stable for the past ten years; however, the total landings of queen conch have been declining (CRFM, 2004). CRFM countries are responsible for over 70 % of the world's queen conch production and trade (CRFM, 2004).

Various studies throughout several parts of the Caribbean region have been carried out on the spiny lobster's biology and distribution (Luckhurst and Auil-Marshalleck, 1995b). In a tagging study conducted in Belize, lobsters less than 80 mm in carapace length (CL) were tagged and lobsters recovered within the initial three months of the study indicated that the lobsters moved randomly over distances between 8 and 32 km, with the rate of travel in some cases being 3 km per day (FAO, 1968). The average growth increment per moult was 8 millimetres for both sexes (FAO, 1968). In Bermuda, a tagging programme for the spiny lobster was initiated in 1997, in which 676 lobsters were tagged (Trott *et al.*, 2003). The data collected from 67 recaptured lobsters, indicated that they also exhibited random movement, with the longest distance travelled being 45.9 km and the average distance travelled by all lobsters being 12.2 km (Trott *et al.,* 2003). The days at liberty ranged from 9 to700 days (Trott *et al.,* 2003). Outside of the region, lobster tagging programmes for *Panulirus marginatus* and *Scyllarides squammosus* have been implemented in the Northwestern Hawaiian Islands (Pacific Islands Fisheries Research Center, 2005) and for *Homarus americanus* in the Gulf of Maine (Cowan, 2003).;

Various studies on conch biology including: growth, mortality and movement patterns have occurred throughout out the Wider Caribbean including a tagging programme in Florida and Martinique (Glazer and Berg, 1994; Rathier and Battaglya, 1994). In Martinique, 200 juvenile conchs, with siphonal lengths of 70-20 mm, were tagged and released with recapture occurring between 1 week and 10 months after release (Rathier and Battaglya, 1994). The von Bertalanffy growth parameters using Faben's method, estimated from this experiment for conch were: L_∞= 338.97 mm and K = 0.392 yr^{-1} (Rathier and Battaglya, 1994). This study also enabled the determination of age. Similar studies in Florida were done to determine population parameters of the queen conch at five sites. The von Bertalanffy growth parameter, K varied between 0.57 and 1.02 (Glazer and Berg, 1994).

4.4.2 Potential Aims and Outputs

Tagging research on the spiny lobster and queen conch would be able to provide information on the growth patterns, stock size and mortality of these resources. In the case of the queen conch, the growth information obtained through tagging studies would also enable age estimation. The tagging studies would also be able to provide tangible evidence on movement and migration patterns of these resources, including the extent of sharing among fisheries. The effectiveness of marine reserves as a source of recruits to adjacent fishing areas could also be investigated through tagging studies.

4.5 Shrimp and Groundfish Resources

4.5.1 Introduction

The targeted shrimp species include: *Penaeus brasiliensis, P. subtilis, P. notialis, P. schmitti and Xiphopenaeus kroyeri,* and the targeted groundfish species are from the Ariidae and Scianidae families. At present, it is believed that several of the shrimp and groundfish resources within CRFM States are fully or over-exploited based on changes in catch species composition, decreased mean fish size and decreased abundance (CRFM, 2004b). In addition to these issues, some the shrimp and groundfish resources are also shared among countries, which are not CRFM Members (e.g. countries on Guianas-Brazil shelf) (CRFM, 2005). This fact underscores the importance of collaboration for management purposes among countries.

To the best of our knowledge, there have been no tagging studies on either shrimp or groundfish within the region. Elsewhere, there has been extensive effort in shrimp tagging research. For example, in the tidal creek subsystems of Sapelo Island, Georgia, 15 974 shrimp *Litopenaeus setiferus* (40 -80 mm TL) were tagged with coded microwire tags and released; 184 were recaptured over a period of two years (Webb and Kneib, 2004). The daily absolute growth rates of individuals, ranged from 0.25 to 2.5 mm and the results indicated that juvenile white shrimp usually remained resident in the upper areas of the creek until they reached between 80−100 mm TL, after which emigration into the ocean occurred (Webb and Kneib, 2004).

4.5.2 Potential Aims and Outputs

Tagging research on shrimp and groundfish resources would be able to provide information on the growth and mortality of these resources. It would also be able to facilitate the validation of any age studies for groundfish that take place as part of a stock assessment. The tagging studies would also be able to provide tangible evidence on the movement and migration patterns of these stocks.

5.0 THE PROGRAMME'S TERMS OF REFERENCE

The terms of reference for the CRFM Fisheries Tagging Programme follow:

1) To facilitate regional coordination and collaboration with respect to the identification and prioritisation of tagging research needs, especially regarding shared and similar resources.
2) To facilitate implementation of priority tagging studies identified by CRFM countries and the CRFM annual scientific meetings.
3) To ensure that tagging studies implemented under the auspices of CRFM adhere to internationally acceptable scientific standards.
4) To establish and maintain a regional fisheries tagging database.

5) To facilitate and monitor the exchange of information derived from tagging studies conducted within CRFM States.
6) To contribute to the fulfilment of research obligations of CRFM States in accordance with regional and international agreements and conventions to which they are signatories/parties. In particular, to facilitate and assist in the analysis of tagging data and in the formulation of scientific advice based on the analyses.
7) To prepare and publish reports of studies completed under the auspices of the Programme. On completion, such reports will be presented for review during the CRFM annual scientific meetings.

In 2007-08, work can commence on the design of the regional tagging database.

6.0 PROGRAMME OUTPUTS SUMMARIZED

1) A regional fisheries tagging database, for use by scientists working on fisheries problems in the Caribbean.
2) As required, determination of the extent of resource sharing among fisheries and other resource users.
3) As required, identification of stock management units through improved understanding of resource distribution, movement and migration.
4) As required, estimates of growth and mortality for those species investigated for these parameters.
5) As required, quantitative determination of the performance of selected management tools, e.g. the capacity of marine reserves to serve as spatial refuges and to enhance recruitment in fished areas.

7.0 BENEFITS TO SPONSORSHIP PARTNERS

Due to the economic and social benefits produced by the fisheries sector within the CRFM region, effective management of these resources is critical to ensure sustainable use and continued economic gain. Many of the fisheries resources within the CRFM region are overexploited, and/or shared by more than one country, which makes the development of appropriate regionally coordinated management measures even more critical.

Tagging studies are among the most widely advertised research initiatives contributing to the management of shared resources and their supporting fisheries. Due to the financial limitations of small island states, programmes such as these usually require funding from external sources. Donor funding support for the CRFM Fisheries Tagging Programme would provide the opportunity for the donor to demonstrate its commitment to environmental stewardship, the sustainable use of the region's fisheries resources, and the sustainable development and maintenance of livelihoods, which depend on these resources including the sportfishing charter industry and its valuable contribution to the tourism industry. Advertising of projects conducted under the auspices of the Programme would occur in all the countries that participate in the project, as well as neighbouring countries with similar fisheries. The advertising strategy would include the use of radio, television and internet media (e.g. articles, presentations and documentaries), as well as brochures, posters, stickers, and clothing. Fish recaptures are usually also advertised when they occur.

8.0 BENEFICIARIES

The main beneficiaries of the CRFM Fisheries Tagging Programme would include:

1) National and regional fisheries administrations, by means of
    - improved management planning and decision as a result of tagging research outputs that contribute to a more scientifically robust understanding of the biology and ecology of the resources, and
    - at least partial fulfilment of research obligations under international agreements and conventions.
2) Staff of national and regional fisheries administrations, through the provision of training opportunities in tagging research and general development of skills in research, data analysis and reporting.
3) The tourism sector, through improved management strategies that facilitate optimisation of the economic benefits derived directly from the sportfishing industry.
4) Participants in the fishery and other stakeholders, through optimisation of the opportunities and social and economic benefits to be derived from a well-managed fishing industry.

9.0 BUDGET

No special budget is required to establish the Programme. When priority tagging projects are identified by individual countries and the scientific meetings, each project proposal will include its specific implementation budget. In 2007-08, work can commence on the database design, using resources currently available to the Secretariat.

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Appendix 8: CRFM Data Policy Outline

1. Goal

(a) To improve the capacity of CRFM countries to provide quality fisheries management advice through the establishment of rules and procedures for the collection and storage of data within CRFM countries, and the use of these data by CRFM Working Groups, during CRFM-managed projects and by individual researchers who request such data.
(b) To ensure adherence to acceptable standards of data reporting to regional and international fora, as prescribed by international fisheries instruments.

2. Scope

(a) Fisheries data collected by CRFM countries and during CRFM-managed projects
(b) Data utilized in analyses conducted by CRFM Working Groups during CRFM Scientific Meetings and by individual researchers who request use of these data.

3. Data Collection and quality

(a) Basic data requirements for all fisheries, and basic data requirements for specific fisheries.
(b) Minimum sampling coverage of fisheries.

4. Data storage, availability and access

(a) Computerization of data and agreed formats for entry of data shared under this policy.
(b) Rules and procedures for ensuring availability and access to national and regional data through time.

5. Ownership of data

(a) National data
(b) Data collected during regional CRFM-managed projects.

6. Contribution of data (reporting) to CRFM

(a) Catch and effort data contributions
(b) Size data contributions
(c) Other data contributions (social economic, environmental)
(d) Procedures for review and incorporation of research data, including TEK/LEK data).
(e) Meta-data and other supplemental information, including, *inter alia*:

- Measurement technique, accuracy and precision
- Raising and analysis techniques
- Quality information/ indicators
- Contact person for queries
- Person(s) or organization(s) to be acknowledged.

All data including meta-data and quality indicators should be submitted using standard agreed codes, formats, and protocols.

7. Dissemination of Data

(a) Procedures required if and when a regional database is established.
(b) Procedures for provision of data to other organizations, as agreed.

8. Use of Data

(a) Data interpretation
(b) Acknowledgement of data sources

(c) Respect for any restrictions on the use or reproduction of data
(d) Products

9. Resources
(a) Human, financial, and institutional

10. Linkages
(a) Exchange and collaboration, e.g. regional and international initiatives.

Appendix 9: IMA Fish Growth Studies

1.0 Background

In a Letter of Agreement between the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) and the Institute of Marine Affairs (IMA) 1995, the Fish Age and Growth Laboratory was established at the IMA by enhancing the already existing fish age and growth research capabilities through the recruitment of additional staff and the procurement of equipment.

The CFRAMP participating countries had originally identified a total of 16 species for ageing using hard-parts by the Fish Age and Growth Laboratory. Later four additional species were added as well as a limited data set of 10 species from a fisheries-independent survey from Alice Shoals, Jamaica, Table 1. The functions of the Laboratory were to provide age estimates as well as corresponding growth curves and growth parameter estimates and where possible, age length keys using hard-parts (spines, vertebrae and otoliths).

2.0 Status

Samples from 20 species were received by the Laboratory. Age estimates were provided for 19 of the species, Table 2. With the exception of the Wahoo *Acanthocybium solandri*, all ages were based on sections of the hard-parts. There were several limitations to the data set noted by Kishore (2003) which affected the generation of growth curves and growth parameters estimates. There was varying clarity in the annuli patterns, with some species being relatively easy such as the lane snapper *Lutjanus synagris*, to difficult, such as the Kingfish *Scomberomorus cavalla*. No discernable annuli pattern was determined for the black fin tuna *Thunnus atlanticus* despite using both whole and some section otoliths and this assessment has to be re-examined.

Growth parameter estimates were developed for eleven species, Tables 2. Most of the parameters can be treated as preliminary because the data set was very limited. In most cases the size range of the fish from which the hard-parts were collected were fairly narrow resulting in either not enough young or old fish present in the data analysis which affected the quality of many of the growth parameters. With the exception of *Balistes vetula*, *Lutjanus vivanus*, and *Lutjanus synagris* it must be noted however that no age and growth studies using hard-parts has been performed on these species for the English- speaking Caribbean.

The growth parameters developed for two species; the Wahoo and the Crevelle jack can be considered successful mainly due the large sample size adequately covering the size range of the species. For the Wahoo this was possible because of the expansion of the data collection period from 1996 to 2003 and the inclusion of samples from both St. Vincent and Trinidad and Tobago. This was only possible as the Wahoo can be considered a single stock in the southern Caribbean. For the Wahoo this age and growth assessment is the first to produce growth parameter estimates. For the Crevelle jack consistent sampling of large number over the entire size range resulted in the relatively good growth parameters.

The results of the research of the laboratory can be found in several reports and has been presented at various fora such as national and International Symposia and CFRAMP/CRFM Workshops and Scientific Meetings.

The current Workplan (2006/2007) of the Age and Growth Laboratory has focussed on the Wahoo and the Crevelle jack. For the Wahoo back-calculated growth curves have been refined. Statistical analysis of the male and female growth patterns are being examined as well as the influence of sea surface temperature on the formation of the annuli pattern present on the whole otoliths.

For the Crevelle jack, re-ageing of some samples were done and re-analysis of the age and growth data is almost completed (August 2007).

3.0 Contribution of IMA

3.1 Staffing and recruitment

Since the initial funding contribution of CFRAMP (1995-1998), the IMA has continued to support the Fish Age and Growth Laboratory. For all the years since 1998, the Annual Work Plan has included fish age and growth research. Since the hiring of staff under CFRAMP, the IMA has hired over the years, four researchers (3 at the postgraduate level and one at a graduate level). At present there are two researchers (at the post-graduate level) attached to the laboratory.

3.2 Equipment

The IMA in 1999 had acquired the new imaging software, Optimas 6.5 and associated frame-grabber used for ageing hard-parts. This software is not compatible with Windows 2000/XP and as such is not operational with the new upgrade in computers at the IMA. The Laboratory however has stilled maintained the Optimas 3.1 imaging system which was originally sourced under the CFRAMP funding, and it is the only imaging software currently available to the Laboratory. Two additional computers were also provided to the laboratory. The Laboratory has the services of both stereo- and binocular microscopes for age and growth research. The Laboratory also has access to the Histology Laboratory and its equipments (oven, fume-hood and balance) for sample preparation.

With the view to upgrade the image analysis system, the IMA (though the University of Trinidad and Tobago) is seeking to obtain the new imaging software, Image Pro-Plus which is compatible with Windows 2000 system. The IMA has also funded the training of the two researchers in the use of this new software in June 2007 in Bethesda, Maryland. In addition, to support the new imaging software, the IMA intends to purchase a new digital camera and new computer to complete the new imaging system.

4.0 Importance of Age and Growth Research using hard-parts

Use of hard-parts for age and growth studies is well established and is routine in many universities (e.g. North America, Europe, Australia) and governmental laboratories and agencies for the purpose of providing age and growth information for stock assessment of commercial species. To date there has been three international Symposia from 1996. Research in this field of science is very active and Campana (2005) noted that a review of 862 otolith-oriented papers published since the time of the 1998 Otolith Symposium in Bergen, Norway to the 3rd Symposium held in 2004, suggests that there has been a change in research emphasis compared to earlier years. Although close to 40% of the papers could be classified as 'annual age and growth' studies, the remaining papers were roughly equally divided between studies of otolith microstructure, otolith chemistry and non-ageing applications. A more detailed breakdown of subject areas identified 15 diverse areas of specialization, including age determination, larval fish ecology, population dynamics, species identification, tracer applications and environmental reconstructions.

5.0 CRFM Second Scientific Meeting 2006 (Plenary report)

There was a general recommendation of the Meeting for the establishment of a formal working arrangement between the CRFM and the IMA Fish Age and Growth Laboratory, similar to the one that existed between CFRAMP and IMA. In addition, one of the conclusions of the Ad Hoc Working Group on Methods was the importance of resuming fish age and growth studies for refining CRFM fisheries assessments.

Specific reference was made where the use of age and growth information was required or considered important. For the king mackerel (*Scomberomorus cavalla*) fishery of Trinidad and Tobago, it was pointed out that the lack of growth parameters probably affected the quality of the results of the assessment.

The meeting was advised that some work on king mackerel had been started by the Fish Age and Growth Laboratory at IMA, but that there was some difficulty in interpreting the otolith markings. It was suggested that it would be very useful for the IMA laboratory to work more closely with a fish ageing laboratory in Florida where king mackerel was also being studied. It was agreed that it was a good idea to compare methodologies used, and that such collaboration could be explored further. While contact was made by the IMA with the Panama City Laboratory Southeast Fisheries Science Center (SEFSC), funding still remains an issue for such collaboration.

The Shrimp and Groundfish Resource Working Group (SGWG) also recommended ageing studies on the red snapper, (*Lutjanus purpureus*) fishery of Guyana. For the lane snapper (*Lutjanus synagris*) fishery of Trinidad while reference was made to previous ageing work conducted by Heileman-Dass (1987) based on a fishery independent study; it was noted that there had been a considerable increase in exploitation of both the inshore and offshore fisheries on the north and east coasts since that study. The need for ageing the species using hard parts was highlighted, and it was suggested that environmental conditions affecting growth could also be investigated. Furthermore, the Tobago component of the fishery should be considered and included in future stock assessment analyses.

6.0 Areas for Collaboration

6.1 MOU between CRFM and IMA

Establish a Memorandum of Understanding (MOU) between the CRFM and IMA/UTT similar to what has existed between CFRAMP and IMA.

6.2 Species for Ageing

There is continued collaboration with the Fisheries Division of Trinidad and Tobago to continue the age and growth studies of Carite, *Scomberomorus brasiliensis*. This research is included in the 2007-2009 Workplan of the IMA. The data set will be expanded to include otolith samples from 1991-1997.

It is suggested based on the recommendations of the Second CRFM Scientific Meeting that the two lutjanid species, red snapper *Lutjanus purpureus* from Guyana and *Lutjanus synagris* from

Trinidad, be the initial species for ageing under the CRFM. Both species have been aged before by the IMA, with the current laboratory personnel having experience with *L. synagris*. Given the work schedule of the Age and Growth Laboratory it is proposed that data collection be over the period 2007/2009 with ageing of samples to commence in 2008/2009.

6.3 Establishment of a Monitoring Program

Most fish age and growth laboratories have ongoing assessment of commercial species as the age structure of commercial catches changes with fishing pressure and growth parameters have to be continually monitored and updated. It is suggested that this be the same for this Laboratory. It is proposed that such monitoring program be initiated with the Wahoo especially given its regional significance and increasing international importance. Countries can select at least one species for re-assessment at least every 5 years.

6.4 Training Workshop

Given the gap in data collection since the CFRAMP Program as well as the recruitment of new personnel to the various fisheries departments in the region it is proposed a training Workshop be conducted which will cover data collection, sample preparation as well some age and growth research techniques which will assist in ensuring adequate sample collection for proper age and growth assessment. The data collection strategy would follow some of the recommendations outlined by Kishore (2001) and Kishore (2002b) in conjunction with those from the respective countries.

6.5 Related fisheries research (Future otolith-based research)

In addition to age and growth research it is suggested that related fisheries biology research of commercial species such as reproductive biology be conducted to complement the age and growth research.

Increasingly the use of otoliths has been used in applications other ageing fish. The otolith micro-chemistry has been used to identify nursery areas and migration patterns, examine the relative contribution of different nurseries to recruitment of fish stocks, as well as in pollution studies. In addition the otolith morphology is being used for stock identification as well as specific recognition in diet composition studies of piscivorous fish. Some of these research areas can be explored with the development of the Laboratory and the incorporation of the IMA into the University of Trinidad and Tobago.

6.6 Capacity building

The research area of fish age and growth is relatively new in the English-speaking Caribbean. The Fish Age and Growth Laboratory based at the IMA is the only one of its kind in the Caribbean. The development of the capabilities of the laboratory would provide a nucleus/focal point for expertise in this research area. The incorporation of the IMA into the University of Trinidad and Tobago would provide for enrollment of M. Sc./M. Phil and Ph. D. students from T&T and the Caribbean and so continue to build capacity in this research area as well as other fisheries research areas. This would further be strengthened with collaboration with international laboratories as well as international researchers and students.

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Table 1: List of species requested for ageing (Large pelagics, Reef, Deep Slope species) under the CFRAM Program.

SPECIES	COUNTRY REQUESTING AGEING													
	Antigua Barbuda	Barbados	Belize	Dominica	Grenada	Guyana	St. Vincent	Grenadine s	Jamaica	Alice Shoals	Montserrat	St. Kitts/Nevi	St. Lucia	Trinidad & Tobago
Acanthocybium solandri		X					XX						X	XX
Scombermorus cavalla												X		X
Thunnus atlanticus		X					X		X					
Caranx hippos												X		X
Sparisoma viride	X							X						
Holocentrus adscensionis				X				X		XXX				
Holocentru rufus				XX										
Balistes vetula			X					X			X			
Haemulon flavolineatum	X							X						
Haemulon melanurum										XXX				
Haemulon parrai										XXX				
Haemulon plumieri										XXX				
Acanthurus chirurgus				X				X			X			
Etelis oculatus	X	X			X							X	X	
Lutjanus synagris			XX	X						XXX				
Lutjanus jocu														X
Lutjanus vivanus	X	X								XXX				
Lutjanus analis	X													
Lutjansu bucanella				XX						XXX				
Lutjanus mahogoni			X	X				X						
Pristopoimoides										XXX				
Epinephelus cruentatus				XX										
Epinephelus fulvus				X						XXX		X		
Epinephelus guttatus	X		X		X					XXX				
Macrodon ancylodon						XXX								
Ocyurus chrysurus			XX											

X – Species from original 1995 Letter of Agreement XX – Species added to original list XXX – Alice Shoals species

Table 2: Samples received under the CFRAMP Biological Data Collection Program for ageing using hard-parts.

Species	FAO Common Name	Total samples Received	Samples Aged	Annular Interpretation
Acanthocybium solandri	Wahoo	Barbados – 62 St. Lucia - 77 St. Vincent – 157 T&T - 531	771 - (whole)	Reasonably clear growth patterns seen on the whole sagitta of this species. No discernable annuli present on sectioned otoliths.
Acanthurus chirurgus	Doctorfish	Monsterrat – 164	120 (whole) 120 (section)	Difficult to age. Annuli patterns on sectioned sagitta were diffuse in the younger age groups and the first annulus was difficult to discern. Older fish were relatively easier to age because the banding patterns were more definitive.
Balistes vetula	Queen triggerfish	Monsterrat - 220	207 (sectioned spines)	Reasonably clear growth patterns seen on the sectioned spines of this species. In older fish the central canal tends to be obliterated, which makes the position of the focus and the first annulus often difficult to determine.
Caranx hippos	Cavali, jack	Trinidad - 332	309 (whole) 307 (section)	Reasonably clear growth patterns seen on the whole and sectioned sagitta of this species. Position of the first annulus difficult to determine on the whole but less difficult to define on the section.
Cephalopholis cruentata	Graysby	Dominica - 35	29	Reasonably clear growth patterns seen on the sectioned sagitta of this species
C. fulva	Coney	Dominica – 48	28	Reasonably clear growth patterns seen on the sectioned sagittae of this species
Epinephelus guttatus	Red Hind	Grenada – 57 Dominica - 13	43	Annuli growth patterns on sectioned sagitta were more diffuse and difficult to interpret than those subsequently formed.
Etelis occulatus	Queen Snapper	St Lucia - 29		
Haemulon plumieri	White grunt	Antigua - 4	4 (whole)	
Holocentrus adscensionis	Squirrelfish	Dominica – 106 + 69*	98 (section)	A relatively clear pattern of alternate light and dark bands corresponding to opaque and translucent bands were observed on the sections of this species.

Species	FAO Common Name	Total samples Received	Samples Aged	Annular Interpretation
H. rufus	Longspine squirrel fish	Dominica – 166 + 111*	153 (section)	A relatively clear pattern of alternate light and dark bands corresponding to opaque and translucent bands were observed on the sections of this species
Lutjanus analis	Mutton snapper	Belize - 3	2 (whole)	Relatively clear annuli patterns present on sectioned sagittae
Lutjanus buccanella	Blackfin snapper	Dominica - 53	36 (whole)	Relatively clear annuli patterns present on sectioned sagittae
L. mahogoni	Mahogany snapper	Dominica - 51	41 (whole)	Relatively clear annuli patterns present on sectioned sagittae
L. synagris	Lane snapper	Belize – 91	88 (section)	Clear annuli patterns present on sectioned sagittae.
L. vivanus	Vermillion snapper	Dominica – 60 Antigua - 15 Barbados - 2	56 (section) 15 (whole)	Clear annuli patterns present on sectioned sagittae
Macrodon ancylodon	King weakfish	Guyana - 8		No discernable growth patterns seen on sectioned sagitta
Ocyurus chrysurus	Queen snapper	Belize - 13	12 (whole)	Relatively clear annuli patterns present on sectioned sagitta
Scomberomorus cavalla	Kingfish	T&T - 250 (177) collected for microstructure analysis	250(whole) 134 (section)	Diffuse growth patterns for younger fish makes it difficult to age fish both on whole and sectioned otoliths.
Thunnus atlanticus	Blackfin tuna	St. Vincent - 158	56 (whole) 20 (section)	Tentative age estimates assigned because of uncertainty of annuli patterns on sectioned and whole otoliths.

*These samples were sent to the Laboratory in March 2002.Due to problems with the embedding medium (only rectified in June 2003) no processing was done on these samples and the age analysis was already completed by researchers who had already left the Laboratory.

Table 3: Growth parameter estimates for commercial species in the Caribbean generated by the Fish Age and Growth Laboratory.

Species	Country	Asymptotic Length L_∞(cm)	Growth Constant K (year^{-1})	t_o (years)	Sample Size (n)	Limitations/Comments	Reports
Acanthocybium solandri	Trinidad and Tobago, St. Vincent, St. Lucia and Barbados	155.21 (FL)	0.316	-1.172	517	Growth curve based on observed mean length at age data. Whole sagitta used for age estimates	R. Kishore 2002a. "Age and growth studies of the Wahoo, *Acanthocybium solandri* (Curvier 1830) from the Southern Caribbean". Oral presentation at the Joint Meeting of the CRFM Pelagics and reef Fisheries Working Groups (2002).
Acanthurus chirurgus	Montserrat	33.43 (TL)	0.086	-5.79	116	Sectioned sagitta used for age estimates Small data set Very narrow size range - 70% came from one 5cm size class range. Absence of young fish and large older samples limited the production of reasonable growth estimates. Breaks in sampling prevented marginal increment analysis (MIA) Absence of sex data which allows for comparison of growth parameters between sexes	Kishore, R. and Chin, X. 2001. "Age and Growth Studies at The CFRAMP/IMA Regional Age And Growth Laboratory – Progress of Work Done and Future Approaches" presented at the 200 Caribbean Pelagic and Reef Fisheries Assessment Workshop. Ramsundar, H. 2007. Age and Growth Studies of *Acanthurus chirurgus* from Montserrat –report submitted for review
Balistes vetula	Montserrat	75.0 (TL)	0.07	-4.437	207	Sectioned dorsal spine used for age estimates Small data set	Ramsundar, H. and Richardson-Drakes, A. 2003. *Age and Growth Studies of Balistes vetula* from Montserrat" – report submitted for review

Species	Country	Asymptotic Length L_∞(cm)	Growth Constant K (year^{-1})	t_o (years)	Sample Size (n)	Limitations/Comments	Reports
						Few samples at the extreme range of the growth curve (young and old) – affected the growth curve and growth parameters	
Cephalophalis fulva	Dominica	46.5 (TL)	0.15	-2.409	24	Sectioned sagitta used for age estimates Small data set Narrow size range Few samples at the extreme range of the growth curve (young and old)	Chin, X. and Richardson-Drakes, A. 2004. Age and growth determination of the coney, *Cephalopholis fulva* and grasby, *C. cruentata* from Dominica. Document Prepared for The CARICOM Fisheries Resources and Assessment Program (CFRAMP). Final Report
Epinephelus guttatus	Grenada	47.25 (TL)	0.133	-3.972	43	Sectioned sagitta used for age estimates Small data set Few samples at the extreme range of the growth curve (young and old) Sampled for only three months – MIA not possible	Chin, X. and Richardson-Drakes, A. 2004. Age and growth determination of the red hind *Epinephelus guttatus* from Grenada. Document Prepared for The CARICOM Fisheries Resources and Assessment Program (CFRAMP). Final Report
Holocentrus adscensionis	Dominica	23.0191(TL)	0.547	-0.9247	98	Sectioned sagitta used for age estimates Narrow size range – 101 of the 106 samples received were in the 16-25 cm size	Solomon, F. and Ramsundar, H. 2007. Age and growth determination of *Holocentrus adscensionis* and *H. rufus* from Dominica. Report submitted for review.

Species	Country	Asymptotic Length L_∞(cm)	Growth Constant K ($year^{-1}$)	t_o (years)	Sample Size (n)	Limitations/Comments	Reports
						range The absence of fish from both ends of the age range has resulted in a low L_∞ and a high t_0 value MIA was inconclusive due to periodic breaks in data collection and small sample size	
Holocentrus rufus	Dominica	20.752 (TL)	0.1343	-10.0	153	Sectioned sagitta used for age estimates Narrow size range – 155 of 166 samples received were in the 16-20-size range The absence of fish from both ends of the age range resulted in a low L_∞ and a high t_0 value MIA was inconclusive due to periodic breaks in data collection and small sample size	Solomon, F. and Ramsundar, H. 2007. Age and growth determination of *Holocentrus adscensionis* and *H. rufus* from Dominica. Report submitted for review.
Lutjanus synagris	Belize	26.5 (TL)	0.13	-10.0	88	Sectioned sagitta used for age estimates Small data set Narrow size range – bulk of samples between 16-30cm	Kishore, R. 2005. Age and growth determination of the Lane Snapper, *Lutjanus synagris* from Belize and Jamaica – Final report.

Species	Country	Asymptotic Length L_∞(cm)	Growth Constant K ($year^{-1}$)	t_o (years)	Sample Size (n)	Limitations/Comments	Reports
						Sample period less than one year (6 months); periodic breaks in sampling. MIA not possible Small sample size and narrow size range has resulted in a very low L_∞ and associated high t_o.	
Lutjanus vivanus	Dominica	58.5 (TL)	0.133	-0.342	56	Sectioned sagitta used for age estimates Small data set Small/limited size range	Richardson-Drakes, A., Kishore, R. and Guiste, H. 1997. Preliminary Age Determination of Silk Snapper *Lutjanus vivanus* from Dominica, West Indies. Presented at the IMA 5th Research Symposium. Oral presentation
Scomberomorus cavalla	Trinidad	197.1 (FL) (female) 199.5 (FL) (male)	0.098 0.086	-2.33 -2.86	129 40	Sectioned sagitta used for age estimates Growth parameters can be considered tentative because poor agreement between primary and secondary readers	Chin, X. 2003. Preliminary age growth studies of the Kingfish, *Scomberomorus cavalla* from Trinidad". Presented at the IMA 10th Annual Research Symposium, 2003. Poster presentation.
Caranx hippos	Trinidad	104.4 (females) 70.9 (males)	0.103 0.188	-1.673 -1.091	115 120	Sectioned and whole sagitta used for age estimates. Few samples at the upper range of the growth curve (old)	Kishore, R. 2003. Age and growth studies of the crevelle jack, *Caranx hippos* from Trinidad using Hard-parts. Presented at the IMA 10th Annual Research Symposium, 2003. Poster presentation. Kishore 2006. Age and growth studies of

Species	Country	Asymptotic Length L_∞(cm)	Growth Constant K ($year^{-1}$)	t_o (years)	Sample Size (n)	Limitations/Comments	Reports
						MIA was inconclusive due to periodic breaks in data collection and small sample size in some months	*Caranx hippos* (crevalle jack) from Trinidad using hard-parts and selected aspects of age and growth studies of *Acanthocybium solandri* (wahoo) and *Scomberomorus brasiliensis* (carite). Presented at (CRFM) Second Annual Science meeting, March 2006. Kishore, R. and Solomon, F. 2005. Age and growth studies of *Caranx hippos* from Trinidad using hard-parts. Proceedings of the 56th annual conference of the Gulf and Caribbean Fisheries Institute Tortola, BVI. Pg 227-240.

Appendix 10: Socio-economic monitoring by Caribbean fishery authorities

The core of the slide presentation followed by discussion will be the CERMES project on *Socio-economic monitoring by Caribbean fishery authorities* to be implemented in selected CRFM Member States from October 2007 to March 2009 with the assistance of an International Coral Reef Conservation Grant and matching funds from CERMES.

In the discussion the presenter will seek responses to some questions that will assist CERMES to design the project details in partnership with the selected countries to meet the specific needs of those countries. We will also try to determine if there is interest in the project from non-selected countries or in other activities that can add value to the project, or be considered parallel or follow-up if additional funding becomes available.

Some questions to be discussed are:

1. Which are the five (5) 'selected countries' that both (a) want the SocMon training and (b) have agreed locations for the study site assessments? We note previous interest as in the table below, but we have no information yet on their proposed study sites.

Expressions of interest received at Special Meeting of the Caribbean Fisheries Forum, 23-24 October 2006 in Guyana	Letters of support supplied for final proposal (note that all countries which expressed interest were contacted)
1. Harold Guiste, Dominica 2. Justin Rennie, Grenada 3. Michael Braynen, Bahamas 4. John Jeffers, Montserrat 5. Andre Kong, Jamaica 6. Vaughn Charles, St. Lucia 7. Raymond Ryan, St. Vincent and the Grenadines	1. Harold Guiste, Dominica 2. Justin Rennie, Grenada 3. Michael Braynen, Bahamas 4. Melissa O'Garro, Montserrat 5. Christopher Parker, Barbados

2. What, if any, optional add-on modules (up to half-day) would be selected or other countries like included? Consider SocMon-related sessions on economic valuation, livelihoods analysis, gender, co-management, MPA management effectiveness, etc.

3. What other aspects of project design, implementation, monitoring and evaluation need to be taken in to account, including covering the costs of additional demands?

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Appendix 11: Update on the Preparation of the Common Fisheries Policy and Regime

Introduction and Background

The current effort to establish a Common Fisheries Policy and Regime at the CARICOM level was initiated at the Fourteenth Inter-Sessional Meeting of the Conference of Heads of Government in Trinidad and Tobago, 14-15 February, 2003. The Heads of Government –

> "***Noted*** *and* ***endorsed*** *the proposals submitted by the Government of Barbados on the imperative of elaborating a Common Fisheries Regime;*
>
> ***Urged*** *that the research also take cognisance of the need to develop international standards for the export of fishery products".*

The Conference returned to the issue at its Fifteenth Inter-Sessional Meeting in St. Kitts and Nevis, March 25-26, 2004 but in a context where certain intra-CARICOM disputes relating to maritime boundaries had been referred for third party resolution. This Meeting of the Conference, *inter alia*: -

> ***"Decided*** *that the elaboration of the Common Fisheries Regime would be independent and separate from and without prejudice to the settlement of maritime boundary disputes between and among Member States and Third Parties;*
>
> ***Reaffirmed*** *the continuation of the mandate to the CARICOM Secretariat to propose a framework for the exploitation and conservation of regional fisheries resources at the Fourteenth Inter-Sessional Meeting of the Conference;*

The Caribbean Fisheries Forum[1], established in the framework of the Caribbean Regional Fisheries Mechanism inaugurated on 26 March 2003, considered the issue at its First Meeting on 27 March, 2003 and, *inter alia* -

> ***"Also noted*** *that over the years fisheries officers and fishing authorities of the Region have posited a common approach to the management of the fisheries of the Region;*
>
> ***Agreed*** *that the CRFM, which was formally inaugurated on 26 March 2003, is now in a position to provide regional leadership with regard to this mandate of the Heads of Government;*
>
> ***Also agreed*** *that the Forum will establish a Working Group, under Rule 11 of the Rules of Procedure of the CRFM to develop a draft position on this matter, for reporting to the Heads of Government through the Ministerial Council and Community Council by 30 June 2003".*

[1] The CRFM Forum comprises Heads of national fisheries administrations of Member States, supported by technical representatives from UWI, FAO, CARICOM Secretariat, and the CRNM

The Twenty-Fifth Meeting of the Conference held in St. George's, Grenada, on July 4 – 7, 2004, revisited the matter and supported a programme of activities to develop the policy and regime, which included, *inter alia:*

(i) National Consultations, informed by draft framework for Regional Fisheries Policy and Regime as adopted by the Second Meeting of the Working Group, June 9^{th} – 10^{th} , 2004 and the revised Reports of the Consultants, to be held in Member States in August -October 2004;

(ii) Convene the Third Meeting of the Working Group in November 2004 to consider the output of the national consultations, the Draft Framework for the Regional Policy and Regime, and a discussion paper to be prepared by the CRFM Secretariat on the implementation mechanism of the Common Fisheries Policy and Regime;

(iii) Convene a regional multidisciplinary workshop of the Member States in January 2005 to consider the output of the Third Working Group and refine the Draft Framework for the Common Fisheries Policy and Regime;

(iv) Convene a legal workshop in early January 2005 to develop a working draft of possible legal arrangements for the Common Fisheries Policy and Regime;

Progress to Date

The CARICOM and CRFM Secretariats have spearheaded the preparation of the CFP&R through a consultative process involving a series of studies, consultations among stakeholders including fishermen, and regional meetings involving officials of Member States and regional experts in fisheries, and marine law and policy.

The Nineteenth Meeting of the COTED endorsed the establishment of an Ad Hoc Legal Working Group and a Socio-economic and Linkage Issues Working Group to undertake further research to inform the elaboration of the draft text of the CFP&R. The Socio-economic Working Group held one meeting in March 2006, and prepared two technical reports containing recommendations on the social, economic and networking issues that should be taken into account in developing the Common Fisheries Policy and Regime.

The Ad Hoc Legal Working Group[2] met on five occasions between January 2006 and February 2007, conducted a comprehensive study of the legal and policy issues, and made recommendations which have had the effect of clarifying and resolving many of the contentious issues that had bugged down the development of the policy and regime. A Special Meeting of the Forum was held in Georgetown, Guyana, October 19-20, 2006, to consider the findings and recommendation of the Working Groups. The Meeting reviewed the submissions, raised issues, identified weaknesses, and provided further guidance and direction to the Working Groups on the development of the CFP&R.

The Fifth Meeting of the CRFM Forum held May 3-4, 2007 in Providenciales, Turks and Caicos Islands, considered the analysis and recommendations of the Legal Working Group including the

[2] The Group consists of legal experts from Antigua and Barbuda, Barbados, Guyana, Jamaica, Trinidad and Tobago, Turks and Caicos Islands, and British Virgin Islands, supported by staff from the CARICOM and CRFM Secretariats.

recommended text of the Draft Agreement Establishing the Common Fisheries Policy and Regime. This meeting accepted the explanations and recommendations of the Legal Working Group and requested that the document be further refined to improve its clarity and coherency. Member States, at the technical level, represented by the CRFM Forum, have therefore now arrived at consensus on all except a few issues regarding the scope and content of the CRF&R. The outstanding issues are deemed more suited for consideration by policy makers.

Content of the Draft Agreement of the CFP&R

The Draft Agreement Establishing the Common Fisheries Policy and Regime lays down the basic principles and rules regarding sustainable use, conservation and management of the aquatic resources under the sovereignty or jurisdiction of Member States of the Community in accordance with the mandate of the Conference and the rights and obligations arising from the Revised Treaty of Chaguaramas and the United Nations Convention on the Law of the Sea and associated instruments. It defines, *inter alia*, a common fishing zone, sets up a regime and conditions for accessing fishing opportunities within the zone by community nationals (natural and legal persons) and nationals of thirds states, and the arrangements for regulating and controlling fishing activities within the zone. Special attention is given to protection of the environment and aquatic ecosystems and conservation of the living resources. Conservation has been elevated to one of the primary principles regulating access to and use of the aquatic resources. The Draft Agreement consists of draft text on several issues arranged under twenty-seven sections as follows:

(1) A preamble;
(2) Vision, Goals and Objectives;
(3) Principles;
(4) Scope of the Policy;
(5) The Common Fisheries Zone;
(6) Access to fisheries resources;
(7) Implementation (Powers of the Implementing Agency);
(8) Conservation and Management of Fisheries Resources;
(9) Data Collection and Research;
(10) Intellectual Property Rights;
(11) Dissemination of Information;
(12) Registration of Fishing Vessels;
(13) Marketing and Trade of Fisheries Resources;
(14) Links with Other Organisations;
(15) Dispute Settlement;
(16) Public Awareness;
(17) Inspection, Enforcement and Sanctions;
(18) Signature;
(19) Ratification;
(20) Entry into Force;
(21) Registration;
(22) Amendments;
(23) Reservations;
(24) Accession;
(25) Withdrawal;
(26) Status of Protocols;
(27) Authentic Text;

The common fishing zone and the conditions of access to the fishable resources therein have been sensitive issues for some Member States which are concerned about the sustainability of the resources and potential negative social and economic impacts on their local fishermen and coastal communities. One of the main concern a during the negotiation regarding the zone was whether the concept of a "common zone" where community nationals, with authorization, would be allowed to fish, was a necessary part of a common fisheries policy and regime within the meaning of the mandate of the Conference and the rules of the CARICOM Single Market and Economy. If the concept of a common zone is deemed a necessary part of the CFP&R, the question which arises is whether access to the fisheries resources therein could be deferred from the date of entry into force of the CFP&R to a future date to be determined by the Member States.

Another related concern by Member States is whether the fisheries sector is subject to the principles and rules of the CSME and if so what is the extent and what are the implications for the fisheries sector.

These concerns have been largely, though not completely, addressed through the research findings and recommendations of the Legal Working Group. After analyzing the mandate of the Conference on the Common Fisheries Policy and Regime, and the rights and obligations flowing from the Revised Treaty, the Legal Working Group arrived at the conclusion that the concept of a common fishing zone is implicit in both the mandate of the Conference and the Revised Treaty and in fact goes to the core of the objects and purpose of both and could not therefore be omitted from the Common Fisheries Policy and Regime. The principles and fundamental freedoms laid down in the Revised Treaty apply to the fisheries sector of Member States. Hence the waters falling under the sovereignty and jurisdiction of Member States, including the internal waters, territorial waters and exclusive economic zones, and the economic activities connected thereto, such as fishing, are without exception, subject to the regulatory framework enunciated by the Revised Treaty.

The Next Steps

While significant progress has been made over the past eighteen months in developing the CFP&R, the document should still be considered to be a work in progress requiring further policy guidance in some areas and legal input in others.

The CARICOM and CRFM Secretariats have retained the service of an expert legal draftsman to review and make refinements to the Draft Agreement Establishing the Common Fisheries Policy and Regime in order to expedite its completion. The legal consultant will recommend changes to the text of the Draft Agreement to improve its precision, clarity, consistency with the Revised Treaty and coherency in achieving the stated goals and objectives. He will submit a Revised Draft Agreement to a meeting of the Expanded Legal Working Group[3] scheduled for August 9-10, 2007 in Barbados, and will make any further changes and refinement recommended. The output of the Expanded Legal Working Group Meeting will be submitted to a Special Meeting of the CRFM Forum in September/October 2007, for review and comments prior to submission of the Revised Draft Agreement to the COTED for policy clearance and resubmission to the Conference through the Legal Affairs Committee.

[3] The Expanded Group comprises legal and fisheries experts from six Member States and regional institutions

Appendix 12: Project GloBAL - Global Bycatch Assessment of Long-Lived Species

Fisheries bycatch has been implicated as an important factor in many population declines, including a greater than 90% drop in nesting Pacific leatherbacks sea turtles (*Dermochelys coriacea*) reported by (Spotila 2000), and similar declines in North Atlantic harbor porpoises (*Phocoena phocaena*), vaquita (*Phocoena sinus*) in the Sea of Cortez, Mediterranean striped dolphins (*Stenella coeruleoalba*), wandering albatross (*Diomedea exulans*) and white-chinned petrel (*Procellaria aequinoctialis*) of the Southern Ocean. (Lewison *et al*. 2004)

Project GloBAL (global Bycatch Assessment of Long-Lived Species) has been working in twelve oceanographic regions around the world to describe the extent and magnitude of fisheries effort, bycatch rates in those fisheries, and where possible to estimate bycatch impacts. In regions that are relatively data rich, Project GloBAL has been summarizing existing reports and publications. In others we have been conducting country0by-country profiles that are combined into regional assessments. In regions lacking spatially-delimited data on bycatch rates and fishing effort, we are partnering with local scientists to conduct rapid assessments of fishing effort and by catch from interviews with fishermen.

In the wider Caribbean region there is limited published data on bycatch and fishing effort. As fishing effort increase across the region and across the globe, the problem of catch of non-target species will be magnified. Several reports and articles have already been released on the subject and pressure is mounting on fisheries managers to deal with the issue. This is an opportunity to contribute to a proactive, thoughtful and defensible region-wide assessment.

If the target species of the fishery can sustain intense fishing effort and if bycatch is proportional to that effort, bycatch mortality levels will increase as fishing effort intensifies, irrespective of the amount of the target caught. Without due consideration, sustainable management of target finfish and invertebrate with slow life histories (figure 1).

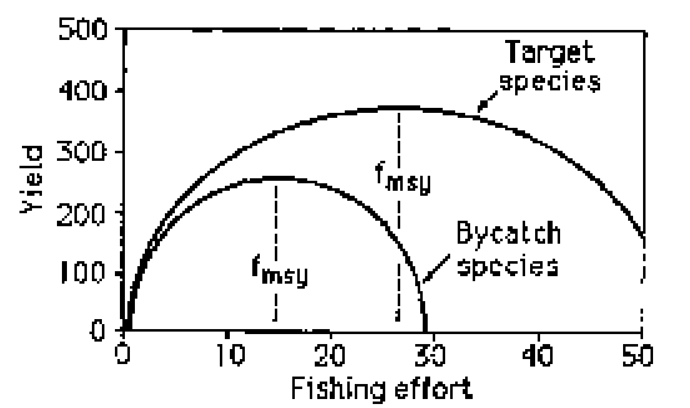

Figure 1: Comparison of MSY for target fisheries and non-target catch. Bycatch species often have contrasting life history (slow growing, late-maturing) strategies.

Update, Caribbean Regional Assessment

1. Regional synthesis

The first draft of the national profiles summarizing information on fisheries and bycatch of air-breathing vertebrates for all the 18 CRFM territories are completed (as of 22/7/2007). The 3rd Scientific Meeting will provide a forum for expert solicitation and input from regional scientist and in-country fisheries biologists and managers.

2. Rapid bycatch assessment

Project GloBAL has received a proposal from Jamaica to undertake a rapid bycatch assessment (RBA) there. We are in discussion with Venezuela and Mexico regarding possible projects in those countries.

3. Modeling overlap of fisheries and bycatch animals

We are collaborating with our Venezuelan colleagues to analyze the Venezuelan pelagic longline observer program to model the relationship between bycatch and oceanography and to compare bycatch rates in this fishery with the US longline fishery.

Our student researchers are also currently examining the feasibility of developing predictive habitat models for eastern Caribbean cetaceans for possible integration with fishing effort maps.

4. Fishing effort mapping

We are collaborating with Fisheries authorities in Bahamas on fishing effort mapping.

Timelines

We seek recommendations from this meeting and the CRFM secretariat regarding timelines for producing the regional report.

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Appendix 13: The United Nation University – Fisheries Training Program

The FTP program in Iceland started in 1998. The main activity since commencement has been an annual 6 months training program in Iceland. The program consist of three elements: 1) 5 weeks core courses for all fellows, 2) 6 weeks of specialized courses within on of the fields of: i) Fisheries Policy and Planning, ii) Stock Assessment, iii) Quality Management of Fish Handling and Processing, iv) Fish Technology, v) Aquaculture and its Environment and iv) Management of Fishing Companies and Marketing, 3) 14 weeks of individual project, including report writing and presentation. The program has 4 permanent staff members and 60-70 additional teachers and supervisors coming from academic and governmental institutes in Iceland. By 2006 144 students have graduated from the program coming from 25 different countries. Additionally, the UNU-FTP has in recent years been promoting and financing a M.Sc. degree at the University of Iceland for fellow graduates.

A new development in the FTP has been the establishment of a short training course with partnership countries. The target participants are people with an academic background that are already working in the fisheries field. So far, two types of short courses have been initiated both in the South Pacific: Fisheries Policy and Planning and a Stock Assessment course. The objective of the latter is to provide an overview on recent developments in fisheries ecology, enhance the knowledge and skills of participants in the design, collection and use of fisheries data and review the elements of current assessment models with emphasis through practical training exercises. The UNU-FTP ultimate goal is that the initiative will be followed up by continuation of and further developments of the course concept. Emphasis is put on establishing cooperative partnership with regional institutions from the beginning, with the aim that they would take over the running of such a continuous education program based on regional needs.