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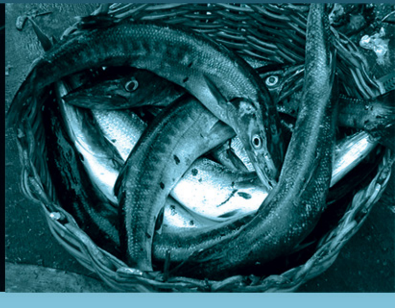
CRFM Fishery Report - 2006

Volume 1

Report of Second Annual Scientific Meeting - Port of Spain, Trinidad and Tobago, 13-22 March 2006



CRFM Secretariat,
Belize & St. Vincent & the Grenadines
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Foreword

The 2006 CRFM Annual Scientific Meeting took place during 13-22 March 2006. During this Meeting, CRFM Resource Working Groups completed eleven of those analyses that were approved by the Third Annual Meeting of the Caribbean Fisheries Forum: queen conch fisheries of Jamaica, The Bahamas, Turks and Caicos; spiny lobster fisheries of the Bahamas and St. Lucia; the shrimp fisheries of Trinidad ad Tobago; the Atlantic Seabob fishery of Guyana; the lane snapper fishery of Trinidad and Tobago; the red snapper fishery of Guyana; the king mackerel fishery of Trinidad and Tobago; the dolphinfish fishery. The Meeting also reviewed and adopted the Report of the First Meeting of the Ad Hoc Working Group on Methods, with amendments.

The Report of the 2006 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 that met during 2006. In respect of the full reports of individual fisheries, the first seven sections (sections 1.1 to 1.7) were reviewed and modified during the plenary meeting sessions. National reports, which had been submitted for consideration by the Working Groups, are published as Supplement 1 to Volume 1, while the Report of the First 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 1.1 to 1.7) of each of the fishery reports. Volume 1 is therefore 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.

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List of Acronyms and Abbreviations

CARICOM	Caribbean Community
CARIFIS	Caribbean Fisheries Information System
CERMES	Centre for Resource Management and Environmental Studies
CFRAMP	CARICOM Fisheries Resource Assessment and Management Programme
CFF	Caribbean Fisheries Forum
CITES	Convention on International Trade in Endangered Species
CLWG	Conch and Lobster Resource Working Group
CPUE	Catch per Unit of Effort
CRFM	Caribbean Regional Fisheries Mechanism
DECR	Department of Environment and Coastal Resources (Turks & Caicos)
DFID	Department for International Development
EEZ	Exclusive Economic Zone
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization of the United Nations
FMSP	Fisheries Management Science Programme
GDP	Gross Domestic Product
GEF	Global Environment Facility
GLM	Generalized Linear Models
GLOBEC	GLOBal ocean ECosystems dynamics
ICCAT	International Commission for the Conservation of Atlantic Tunas
IDRC	International Development Research Centre
IFREMER	Institut fançais de recherche pour l'exploitation de la Mer (French Research Institute for Exploitation of the Sea)
IMA	Institute of Marine Affairs
IOCARIBE	Intergovernmental Oceanographic Commission
IUU	Illegal, Unreported and Unregulated
JICA	Japan International Cooperation Agency
LAPE	Lesser Antilles Pelagic Ecosystem Project
LFDA	Length Frequency Distribution Analysis
LME	Large Marine Ecosystem
LPWG	Large Pelagic Fish Resource Working Group
LRP	Limit Reference Point
LRS	Licensing and Registration System
MEY	Maximum Economic Yield
MFPF	Marigot Fishing Port Facility
MSY	Maximum Sustainable Yield
MT	Metric Ton
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OECS	Organization of Eastern Caribbean States
SCCF	South Coast Conservation Foundation

SCPWG	Small Coastal Pelagic Fish Resource Working Group
SCRS	Standing Committee on Research and Statistics
SEFSC	Southeast Fisheries Science Center
SGWG	Shrimp and Groundfish Resource Working Group
RSWG	Reef and Slope Fish Resource Working Group
TAC	Total Allowable Catch
TCI	Turks and Caiços Islands
TED	Turtle Excluder Device
TOR	Terms of Reference
TIP	Trip Interview Programme
TURF	Territorial Use Rights in Fisheries
UNDP	United Nations Development Programme
USA	United States of America
UWI	University of the West Indies
VPA	Virtual Population Analysis
WECAFC	Western Central Atlantic Fishery Commission
YPR	Yield Per Recruit

REPORT OF THE CRFM ANNUAL SCIENTIFIC MEETING - 2006

1. Opening of the meeting

The Deputy Director of the Trinidad and Tobago Fisheries Division, Ms. Christine Chan A Shing chaired the Opening Ceremony. Ms. Chan A Shing welcomed participants, and made apologies on behalf of the Honourable Minister, Mr. Jarette Narine, who was unable to be present for the Opening Ceremony. Ms. Chan A Shing then introduced the speakers. Mr. Milton Haughton, Deputy Executive Director of the CRFM Secretariat, was invited to address the participants. Mr. Haughton took the opportunity to inform participants of ongoing initiatives by the CRFM to nurture closer ties among CRFM Member States in respect of managing fisheries resources and optimizing benefits on a regional scale, with particular reference to the impact of the CARICOM Single Market and Economy and the establishment of CARICOM's Common Fisheries Policy & Regime.

The feature address was delivered by Mrs. Philippa Forde, Permanent Secretary in the Ministry of Agriculture, Land and Marine Resources, who emphasized the growing importance and essential role of the fishing industry within the context of world trends in the production and trade of crops and livestock. Mrs. Forde also noted the ongoing effort to update national fisheries legislation and to implement an active Monitoring, Control and Surveillance system. Dr. Susan Singh-Renton, Programme Manager, Research and Resource Assessment, CRFM Secretariat, gave the vote of thanks.

2. Election of chairperson

Ms. Chan A Shing proposed that Mr. Haughton serve as Chairperson of the meeting. This proposal was seconded by the representative from the University of the West Indies (St. Augustine Campus), Dr. Indar Ramnarine.

3. Adoption of meeting agenda and meeting arrangements

The agenda was presented. It was proposed that items such as data policy and the establishment of a scientific committee should be addressed during the present meeting. The meeting agreed to include these points under agenda item 11. The meeting agenda was adopted with these minor additions (Appendix 1).

Ms. Elizabeth Mohammed and Mr. Asif Khan, both of the Trinidad Fisheries Division, volunteered to serve as rapporteurs for the plenary session.

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

The meeting was informed that national reports were submitted to the CRFM Secretariat by The Bahamas, Dominica, Guyana, St. Kitts (information from Nevis was not included), St. Lucia, Trinidad and Tobago, and Turks and Caicos Islands. These national reports are published in Supplement 1 to Volume 1 of this Report.

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

6.1 First session

The Chairperson of the First Meeting of the CRFM Ad Hoc Working Group on Methods, Ms. Lara Ferreira, presented the Report of this Meeting (published as Supplement 2 to Volume 1 of this Report).

Several participants commended the Working Group for the amount of work covered during the first meeting. It was asked whether the Working Group had referred to relevant documentation on the various national biological sampling programmes conducted during the mid-1990s under the guidance of CFRAMP. It was clarified that many of the Working Group members had been directly involved in the enhanced sampling programmes implemented by CFRAMP, and so would have been fully aware of the possibilities for resuming such field programmes, as well as the challenges. However, one of the consultants noted that it would have been useful for the Group to have had the written documentation available to it at the time.

Regarding the recommendation for an expert in socio-economic analyses, the meeting was reminded of recent work done both by CRFM and FAO. In 2002-03, Scales Consulting Limited had examined ways of improving the incorporation of social and economic data into the fisheries management process. In 2004, FAO supported a project and several case studies aimed at understanding better the socio-economic dimension of fisheries.

The meeting was then reminded of the changing global environment with regard to fisheries management, and hence the importance of fulfilling data needs to strengthen the capacity of countries to participate effectively in international fisheries management fora. The revival of more detailed field data programmes was crucial to the achievement of sustainable development for CRFM countries. Additionally, care was required in ‘packaging’ the concern about data and communicating this to the decision-makers.

The point was made that the region has been surviving for a long time with making decisions using limited data, and a query was raised whether the Working Group considered the extent to which improved data programmes would improve decision-making. In response, one of the consultants noted that he had never been in a situation where too much information was bad. In fact, considering that the industry was always seeking to improve and expand operations in the form of bigger vessels and other technology changes, and to increase yields and benefits simultaneously, it was crucial to plan and expand the supporting information base.

A query was raised regarding the Working Group’s recommendation to have a socio-economic analyst recruited. It was clarified that the relevant recommendation was for such an expert to be available for the second meeting of the Working Group. It was agreed that the Working group report would be edited to ensure that this idea is stated clearly.

The important role of information, especially in limited resource situations, was also emphasized. The meeting was then informed of the efforts by Trinidad and Tobago to maintain its FISMIS (fisheries information) database. The establishment of a regional information system should be given serious consideration. Mr. Haughton thanked Trinidad and Tobago for its efforts to maintain FISMIS, and recalled the proposal formulated by Trinidad and Tobago a few years ago in respect of establishing a regional information system.

Regarding the recommendations intended to facilitate training and support in the procedures for developing more operational management objectives, it was pointed out the Working Group report should be amended to reflect the ongoing efforts by the Secretariat to assist countries in the development of their fisheries management plans. The meeting was then reminded of the types of activities already being undertaken by the Secretariat to deal with the issue of fisheries management plans and development of management objectives. The usefulness of the FMSP Guides was noted, as well as the importance of the countries leading the process. It was further pointed out that all the stakeholder categories should be identified and provided with full information to ensure more productive consultations for developing fisheries management plans. It was clarified that the Working Group was simply trying to work out the process for developing more operational objectives, and that the recommendations provided options for introducing suitable processes to the countries and helping them to implement them. Further work is required on the actual process to be recommended, and consideration may be given at the second Working Group meeting on whether the new FMSP 'Managers Guide' (developed since the first meeting) can be adopted to facilitate communication in management planning within the region.

In response, it was noted that while it was logical for countries to list broad objectives initially, it was important to analyse this further to determine specific operational objectives. The distinction between short-term and long-term goals and the need for constant communication between scientists and managers were again emphasized. It was noted that the present CRFM Working Group devoted to analyzing socio-economic linkages for informing development of the Common Fisheries Policy also experienced some difficulties in interpreting objectives.

The meeting was cautioned that country management plans and agreed objectives were already being developed following a consultation process, and that the present broad objectives probably represented the limits that countries were willing to accept and work with. It was pointed out that the scientists must recognize that they may never receive precisely-defined objectives from the CRFM countries. In response, it was noted that there was also a danger in scientists giving point estimates to satisfy broad objectives, and which did not give managers adequate choice in their decision-making.

It was suggested that this issue could be brought to the attention of managers at more senior levels (i.e. Forum and Ministerial council) using the formal reporting structure within the CRFM. The meeting was then urged to find ways of effectively communicating the technical results to managers. Reports to be presented to the Caribbean Fisheries Forum and Ministerial Council meeting should be short and should employ non-technical language.

Regarding the methods of analyzing economic data proposed by the Working Group, it was pointed out that the options provided by applying econometrics should also be investigated. In response to management needs, different types of economic data could be collected and analysed to advise management on the cost-benefit ratio.

The need for close collaboration among members of the Working Group in facilitating continued activities during the inter-sessional period was emphasized. It was suggested that an e-group could be formed to facilitate this. It was also re-confirmed that the Forum had agreed to two other meetings of the Working Group, expected to take place annually during the next two fiscal years. Given that Working Group recommendations were noted in different parts of the report it was agreed that a list of all these recommendations be prepared and circulated to facilitate further focused discussion and conclusions.

6.2 Second session – review and conclusions in respect of recommendations made by the Ad Hoc Working Group on Methods

The importance of resuming fish age and growth studies for refining CRFM fisheries assessments was emphasized. The meeting also accepted the amended Terms of Reference for the Methods Working Group. Additionally, it was pointed out that the Terms of Reference should be further modified to permit the Working Group on Methods to establish smaller working groups as deemed necessary.

The list of recommendations made during the First Meeting of the Ad Hoc Working Group on Methods was then reviewed and discussed. Following review of these recommendations made by the Ad Hoc Working Group on Methods during its first meeting, it was agreed that the existing CRFM activities, such as national fisheries consultations, provide an adequate opportunity to introduce managers and stakeholders to the process of analyzing their broad goal statements to develop operational objectives that could be used to guide fisheries monitoring on a day to day basis. Hence there was no need to devote a special separate workshop to address this issue.

There was some discussion about the necessity to reach positions of compromises during manager-stakeholder negotiations dealing with the simultaneous fulfillment of conflicting objectives. It was pointed out that in the USA, a decision support system of decision-making is applied, and that this type of system could be usefully applied in CRFM fisheries management situations. Having noted this, the importance and common difficulty of identifying the decision of priority interest was highlighted.

Some clarification was sought regarding the regional database of life history parameters for crustaceans and finfish, given the existence of FISHBASE. The meeting was reminded that FISHBASE covers only finfish. It was also explained that the Working Group was still developing the idea, and would avoid unnecessary overlap.

6.3 Recommendations

(i) The meeting endorsed the need for 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.
(ii) The meeting endorsed the two additions to the Terms of Reference proposed by the Ad Hoc Working Group on Methods.
(iii) The meeting recommended that the Working Group's Terms of Reference be further modified to give due recognition to the status of smaller working groups formed by the Ad Hoc Working Group on Methods. The fully revised Terms of Reference are given in Appendix 3.
(iv) The meeting recommended that CRFM activities, such as national fisheries consultations, should be used to introduce managers and stakeholders to the process of analyzing their broad goal statements. A special separate workshop was not needed at this time to address the issue.
(v) Regarding the recommendations on data, the meeting agreed that the framework for harmonized sampling programmes and for establishing a central, regional fisheries data and information system should considered as a single exercise, and it was suggested that these recommendations be combined.

The recommendations, and amended recommendations, received from the Ad Hoc Working Group on Methods and accepted by the Meeting, are given in Appendix 4.

7. Reports of the CRFM Fisheries Working Groups

7.1 Reef and Slope Fish Resource Working Group (RSWG)

The Chairperson and Rapporteur for this Working Group were not present for the proposed meeting of this Working Group. Data on red snapper (*Lutjanus purpureus*) were submitted by Guyana. A Fisheries Officer from Guyana had prepared to analyse the red snapper data. In view of the absence of both the chairman and rapporteur for the RSWG, and the fact that the Guyana red snapper fishery shared similar characteristics with the lane snapper (*L. synagris*) fishery of Trinidad and Tobago that was being addressed by the SGWG, The Guyana snapper analysis was conducted under the guidance of the SGWG.

There was some discussion regarding the reason for the absence of the chairman and rapporteur. The Secretariat was asked for and provided a brief explanation of the details. It was agreed that the inability of the Working Group to meet and function as planned would negatively impact the advancement of assessment of the resources covered by the Group, as well as the countries relying on the management advice expected to be generated. The importance of fulfillment of the obligations associated with acceptance of chairmanship and rapporteuring responsibilities was emphasized. It was further recommended that persons should not offer to serve in these roles if they are unable to contribute effectively, as agreed at the regional level.

7.2 Conch and Lobster Resource Working Group (CLWG)

The full report of the Working Group is given in Appendix 5.

7.2.1 The spiny lobster (*Panulirus argus*) fishery of St. Lucia

A query was raised about the change in the closed season for the spiny lobster fishery of St. Lucia, and whether the Working Group attempted to estimate the impact of the change in this management measure. It was clarified that the proposal to change the closed season was made as a result of the findings of a recent scientific study of the resource, and consultations with stakeholders. Considering the positive result of the analysis and the apparent efficiency of the present management regulations, there was a suggestion that the language of the report could be strengthened. However, it was pointed out that the management regulations included an element of flexibility in their enforcement. Additionally, there was evidence that lobsters smaller than the legal minimum size limit were sold to restaurants, and hence the regulation was not perfectly respected. It was pointed out that while the results were positive, the data series was short and also the length frequency data used were comparatively old. There were some inconsistencies in the data, and the Group was able to fix only some of the problems. Essentially, the data used were unverified, and there was a need to review the available data to identify sources of error. A query was raised regarding the observed apparently dramatic fluctuations in effort and in landings over time. It was pointed out that the CPUE trend was the most accurate as the other data were raised.

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

It was noted that the assessment report did not make any reference to the problem of poaching. The meeting was advised that the government of the Turks and Caicos Islands is planning to undertake a survey to estimate biomass of conch. If the model results were found to be consistent with the findings of the survey, this could provide an indication of the level of poaching.

7.2.3 The queen conch (*Strombus gigas*) fishery of Jamaica

Considering the cost of surveys, clarification was sought regarding the justification for the recommendation to undertake visual surveys annually. It was pointed out that a survey for this year had already been approved. The meeting was advised that repeating the survey annually would allow robust estimation of survival rates, and also provide estimates of exploitation rate, poaching and catchability coefficient. Three years of data would provide an indication of the stability of the assessment results from year to year. Hence, it was highly desirable to conduct surveys for at least the next three years, before determining that they could be done less frequently.

It was asked whether poaching could be estimated by other methods. In response, it was explained that a survey of effort could be compared to reported effort. Additionally, it was pointed out that most industries often devote a portion of their revenue to advancement of the science, and then enquired whether CARICOM had ever undertaken to derive an estimate of the appropriate level of funding for research activities by the industry. Participants could not confirm whether such an estimate was available, but thought not. However, it was pointed out that the Jamaican government could examine its legislation to formalize the investment by the industry, as present funding was facilitated through an informal arrangement. It was emphasized that as countries become more active in their management practices, this would enhance the chances of securing funding from the industry and other sources. The importance of the issue of funding and bringing this to the attention of the Forum and higher bodies of the CRFM was highlighted. It was suggested that a policy-level decision would help to guarantee sustainable and also reasonable levels of funding.

There was also some discussion about the CRFM regional conch proposal that had been submitted to FAO. The FAO representative indicated that a sufficient number of countries had not identified this fishery as a priority concern at this time. The meeting then received a brief review of the efforts by Belize in examining its conch fishery in order to produce the necessary information on fishery performance in response to CITES concerns. The meeting was informed of the planned FAO-CRFM conch meeting, scheduled to be held in Jamaica in May. It was noted that a CITES representative would be present at the meeting.

As several recommendations were noted in the report, the importance of prioritizing recommendations to facilitate improved assessments in the future and of establishing an implementation schedule for the agreed tasks was emphasized.

7.2.4.The queen conch (*Strombus gigas*) and spiny lobster (*Panulirus argus*) fisheries of The Bahamas

A clarification was sought regarding the methodology for converting weights to carapace lengths; the necessity of including this information in the report was noted. In response, it was indicated that length to weight ratios were developed using samples from processing plants and that this ratio was applied to compile the wider data set (1988-2004 time series). A possible error in figure 1 was pointed out, and it was agreed that this was observed, and would be rectified.

The comment was made given such a good fit to the model, the effort appeared to be twice the level needed to produce the MSY, and queried the possibility of a fishery crash. In response, it was explained that the parameter estimates were not stable, even though the fit seemed reasonable. The meeting was also cautioned that there were limitations in using short data time series; these posed a difficulty for determining where managers may want to be relative to the MSY position. The Working Group had identified a need to attempt area-specific analyses, and possible also a composite model in the near future. The Working Group was reminded of the importance of addressing the CITES concerns, and cautioned about the wording used in the management summary prepared. Considering the CITES concern, it was suggested that the detailed report should reflect what, if anything was done, to inform the model before the time series started. Unfortunately, information during the early days of the fishery was not available to facilitate this.

7.3. Shrimp and Groundfish Working Group (SGWG)

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

7.3.1. The Atlantic seabob (*Xiphopenaeus kroyeri*) fishery of Guyana

It was noted that increases in fuel prices and taxation had greater impacts on incomes rather than catch variability. Since other income support mechanisms may be used to cope with the problem household surveys could be employed to investigate this. It was suggested that the associated management advice may extend beyond the conventional gear and effort controls. The use of industry pressure on governments to subsidize fisheries was another coping strategy to deal with increasing fishing costs.

Considerable discussion focused on the wording of the report, particularly the management advice sections which appeared contradictory or lacked supporting data or analyses. There was need for clarity in presenting recommendations to managers. In many instances contradictory statements were due to the omission of information quantifying the uncertainties of the model. It was highly recommended that data confidence be quantified in the document. The meeting was advised that data, which could not be explained, were excluded from the analyses. Rather than suggesting that the model was good, and risking no further support or opportunity for its improvement, it was preferred to provide management advice even though the data and model were likely questionable. It was suggested that greater attention be paid to the wording of the report, in order to avoid undesirable reactions from managers. It was therefore recommended that the assessment reports undergo a process of technical editing and that source documents be properly cited in the reports.

Specifically, the discrepancy in advice i.e., reduction in the number of operators in the fishery to stabilize net incomes was noted and it was suggested that the statement be reworded to reflect that the net income for fishers remaining in the fishery would be stabilized in the long term with reduction in the number of participants in the fishery. Further, it was noted that the supporting analyses for the recommendation were not contained in the report presented. The collection of information to explore the impacts of this recommendation was suggested for inclusion in the report.

7.3.2 The shrimp fisheries (*Farfantepenaeus notialis, F. subtilis, F. brasiliensis, Xyphopenaeus kroyerii*, and (*Litopenaeus schmitti*) shared by Trinidad and Tobago and Venezuela

There was concern regarding the proposed closed fishing season even though the issue had been discussed with stakeholders on many occasions. The meeting was advised that local fishers would be disadvantaged by such an arrangement given the high level of poaching by foreign boats. It was explained that the management advice arose from a joint assessment between Trinidad and Tobago and Venezuela and that both countries were expected to implement the proposed measure if the benefits were to be realized.

Further, it was noted that similar recommendations (fleet reduction) arose from assessments on the fishpot and line, as well as the gillnet and line fisheries. Since poaching undermined management measures, it was suggested that options for data collection be explored e.g., local fisher interviews, and use of information from monitoring, surveillance and enforcement activities. It was also argued that it was very important to increase fishers' awareness of the need for data to perform assessments, and of the need for accuracy in the data provided, given the potential impacts of the management measures recommended.

The social and economic impacts of implementation of a closed season were also considered. The examples of closed seasons in Guyana and Jamaica were used to emphasize the need for socio-economic analyses. It was pointed that a key issue was the decline in CPUE trends and the need to address this urgently. Any delays in action would make it more difficult for fishers. The recommendation for a closed season was therefore provided as a compromise position to minimize the negative social and economic consequences.

The meeting was advised of the need for the scientists to consider also the impacts of pollution from land-based sources, seismic activity associated with oil and gas exploration and environmental impacts due to outflows from the major South American rivers on the fish stocks. A request was made to investigate the impacts of pollution and energy-based activity on the fish stocks in the waters of Trinidad and Tobago. The meeting was then reminded that the issues were raised previously at a stakeholder meeting in Trinidad last year and that the Trinidad Fisheries Division was in the process of updating a previous study to investigate the impacts of pollution in the Gulf of Paria. The study was intended to review new information made available since an earlier study; however, it was not yet possible to advise how the results could be incorporated into the assessment model. It was further argued that it would be difficult to incorporate the effects of pollution in the current model. However, if the model was improved to include individual growth and environmental variables, it may be possible to consider this in future. It was agreed that the study recommendations would be modified accordingly. The meeting was then informed of an incomplete study by UWI (St. Augustine Campus), which had attempted to relate pollution levels in the Gulf of Paria with fish fecundity levels. It was emphasized that managers should consider the impacts of pollution and changing environmental conditions in their decision-making.

Similar recommendations as for the report of the Guyana Seabob fishery were made regarding the wording of the management advice, expression of model uncertainty in the report and citation of references used.

Regarding the requirement for updated legislation to facilitate a reduction in fleet size there was an enquiry as to whether or not there was secondary legislation to support this rather than the lengthy process of updating current legislation. It was explained that under the current Fisheries Act (1916) there were provisions for implementation of a closed season but a 1988 Cabinet decision facilitated a cap on fleet size. In light of the limitations of the current legislation, the closed season was recommended as an option that could be implemented in the immediate future.

The need for data collection for assessment of the social and economic impacts of proposed management measures was discussed at length throughout the entire plenary session. It was suggested that a Working Group be assigned to address these issues at the Scientific Meetings. The meeting was reminded that the Ad Hoc Working Group on Methods had recommended that an expert in socio-economic analyses be made available to advise on the process data requirements and analyses, appropriate models and possible constraints. It was recognized that this would be an iterative process that would grow and evolve with time, similar to that experienced with stock assessments. Various sources of pertinent information were cited, including two previous initiatives by the CRFM. The upcoming (June 2006) FAO Expert Consultation on Socio-Economic Aspects related to implementation of the Ecosystem Approach to Fisheries was brought to the attention of the meeting as another source of information.

The need for stakeholder consultation in addressing the recommendations of the Scientific Meeting was emphasized. It was emphasized that management objectives derived from consultation with the industry would drive the science. The agreed objectives should be clearly articulated so that they provide clear guidance to scientists regarding the types of analyses required for each fishery.

7.3.3. The red snapper (*Lutjanus purpureus*) fishery of Guyana

Regarding the management objective to optimize production for export and tourist markets, which were currently developing, it was pointed out that the fishery had been export-oriented for some time and that it was developments in the tourist markets that were more recent. However it was agreed that since the management objectives were taken from Guyana's Draft Marine Fishery Management Plan the meeting was not at liberty to change the wording. The specified management objectives were considered suitable for quantifying what was needed. It was suggested that the recommendation for increased catch and effort data collection at several sites may not be relevant as snappers are landed at only a few sites in Georgetown. The information available to the Working Group may have been limited.

A suggestion regarding introduction of biodegradable panels in fish pots was proposed as a management measure. However it was noted that the fishery was mainly a line fishery; pots were introduced, but fishers were reverting to line fishing.

Data were unavailable to explore the management recommendation to include as many of the existing participants in the fishery. It was therefore suggested that either the data requirements be specified or a recommendation made to change the management objective. It was recognized that data collection plans should be revised to enable better evaluation of management objectives.

It was felt that there was inadequate supporting data to justify a reduction in fishing effort, especially since the optimal levels of effort have not been reliably determined. It was clarified that the species was not a major species caught in trawl nets since *L. purpureus* was not present in soft-bottom muddy substrates where trawling occurs. *L. synagris* were more frequently caught by trawlers.

The Working Group's recommendation for ageing studies on the species was also considered, and the meeting was reminded of the IMA's age and growth laboratory that was equipped to conduct such studies. The IMA Fish Age and Growth Laboratory had been established in the mid 1990s, with assistance from CFRAMP.

With reference to the lack of data from some countries and the impacts on the quality of the assessments it was noted that countries should be encouraged to participate in the Scientific Meetings and to fulfill their agreed commitments. It was noted that the rapporteur who had suggested the inclusion of bangamary (*Macrodon ancylodon*) and sea trout (*Cynoscion virescens*) at the last Scientific Meeting was absent at the present meeting. It was suggested that data could still be sent to the Meeting if participants were unable to attend.

The Working Group was advised to consider inclusion in the summary report of a suitable graph selected from those appearing in the detailed report.

7.3.4. The lane snapper (*Lutjanus synagris*) fishery of Trinidad

Explanations were sought regarding the lack of large snappers in the samples examined from the commercial catch. It was noted that based on the L_∞ and mean size model, very small sizes were generated by analyses. However, the absence of large snappers in the commercial catch samples may have been due to inappropriate sampling design in terms of coverage of landing and fleet types as well as gear selectivity.

The meeting was then advised that there was no longer a local industrial fleet targeting snappers with fishpots. It was further noted that some artisanal fishers used pots off the north coast of Trinidad and in the Gulf of Paria. However, there were boats from Venezuela using lines and targeting snapper resources off Trinidad's east and north coasts.

Reference was made to previous ageing work conducted by Manickchand-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.

Specific recommendations were made regarding the wording of the Management Advice section of the report. In response to the suggestion that management be advised to maintain and monitor fishing effort, it was noted that lane snapper was taken in a multi-species fishery and that previous assessments of other groundfish species, caught by the same gear, recommended no further increase in effort. The practicality of the mesh size regulation recommended by Manickchand-Dass (1987) was also questioned, especially since it was never implemented. The meeting was advised that from a scientific perspective, one should not advise whether an increase or decrease in fishing effort would be precautionary; in fact, even maintaining current effort levels may not be viewed as 'precautionary' by some.

Further clarification was sought on the recommendation to have 'external researchers' conduct stock discrimination studies. It was felt that the University of the West Indies, through its graduate programme, could address this matter. Reference was made to the development of closer ties between the CRFM and the UWI in the area of research. The meeting was advised of the capacity of UWI, St. Augustine campus, to conduct molecular studies, and of the possible support that could be provided to the CRFM. It was suggested that stock discrimination/genetic studies be considered for the future; funding would have to be sourced to conduct such studies.

7.4 Small Coastal Pelagic Fish Resource Working Group (SCPWG)

Given the absence of the Chairman of the SCPWG, the Group was unable to meet formally to assess the status of the species groups identified at the First Annual Scientific Meeting.

7.4.1 Small coastal pelagic fisheries

Landings data on small coastal pelagic fisheries from both Trinidad and Saint Lucia had been submitted this year, but could not be analyzed. Available data from Grenada had not been updated since the last Meeting. Only one country responded to a questionnaire, which had been developed by the chairman, and which was designed to identify management objectives and associated measures implemented, current data collection activities and possible future studies on small coastal pelagic species.

The meeting noted that a 1996 Workshop, hosted by the CFRAMP, focused on small coastal pelagic fisheries. Methods for improved data collection, as well as options for assessment and management were recommended but many of these remain to be implemented. It appears, based on country responses, that the importance of small coastal pelagic resources is grossly underestimated. The associated fisheries play an intimate role in poverty alleviation and socio-economic stability in some of the more disadvantaged rural communities in the region. Although their contribution to employment and food security is widely recognized, these fisheries have seldom been valued in the economic, social and ecological sense.

The species targeted by small coastal pelagic fisheries are used both as a source of food as well as bait in the developing large pelagic, offshore fisheries targeting tunas, billfishes and dolphinfish. Since small coastal pelagic species are natural prey of offshore large pelagic fishes, their abundance and distribution directly impact on the availability of large pelagic species for the offshore fishery. This natural predator-prey linkage highlights the need to assess and manage small coastal pelagic resources. Experience with assessment and management of similar resources elsewhere, has shown that small coastal pelagic resources are particularly susceptible to changes in environmental conditions. They are also most affected by coastal development and have been known to collapse without warning. Considering the points raised above, it was recognized that a greater commitment was necessary on the part of participating countries if small coastal pelagic fisheries are to be assessed and managed in a manner that ensures long term sustainability.

7.4.2. The Flyingfish (*Hirundichthys affinis*) fishery

An informal decision was taken, prior to this meeting, that the status of flyingfish would not have been assessed during the Second Annual CRFM Scientific Meeting, as the FAO representative had indicated that the WECAFC Ad-hoc Flyingfish Working Group would be handling the assessment later in 2006. It was agreed informally that the SCPWG would instead have given priority simply a review of available data and data formats in preparation for the FAO Ad-hoc Working Group assessment later in the year.

However, in response to data submission requests made by the rapporteur in February, flyingfish data were provided by only three countries: Dominica, Saint Lucia and Tobago. Dominica's recorded catch data was summarized by gear, location and month for the periods 1996, and 2000 to 2005. Saint Lucia's data represented individual trip records with details on date, location, gear type, quantity of gear used, soak time and landing weight for 1995 to 1996 and 1999 to 2005. For Tobago, estimates of total landings of the drifting fishery, available by landing site, month and species, between 1988 and 1997 were provided by the Trinidad Fisheries Division. However recent estimates of total landings were not available. Individual trip records with details on gear used, crew number, time spent at sea, area fished and landing weight are also available for 1988 to 1997. In addition, length frequency and maturity data collected in 1991 and 1996 to 1998 were also available.

The low country response did not facilitate a review of regional data that could be useful for future assessment activities. It was also the intention that appropriate assessment models could have been identified, based on these data. This would have facilitated preparation or modification of data by the respective countries so that information could be standardized and be made readily available in the required format for analysis at the planned 2006 meeting of the FAO WECAFC Ad-hoc Working Group. The reports of the FAO WECAFC Flyingfish Working Group's first and second meetings in 1999 and 2001 respectively, contain summarized catch and effort data by country for limited time periods, preliminary analyses of catch per unit of effort data, and the findings of a cost and earnings study. Little is known however, of the existence or availability of biological, social and economic information. It was pointed out that data requests prior to the Meeting were unclear, and there was some discomfort because data were being shared informally between officers. In response to this, the essential roles and responsibilities of the Working Group Chairpersons and Species Rapporteurs were highlighted, in ensuring timely preparation and preliminary analyses of data prior to the Working Group meetings. However, it was argued that the establishment of a Scientific Committee would guarantee formalization and smooth implementation of the inter-sessional activities, including compilation of data on shared resources such as flyingfish.

It was noted that flyingfish (i.e. *H. affinis*) had been extensively studied in the region. The meeting was informed that a 41 page selected bibliography was available. The meeting was then reminded that the species was the focus of an IDRC-sponsored Eastern Caribbean Project in 1988, which introduced data collection systems (catch and effort and biological), conducted age and growth studies, examined movement and migration through tagging studies, investigated maturity and spawning activity, and examined the stock-recruitment relationship. During the same project, a preliminary yield per recruit analysis was also conducted, the results of which implied that YPR analyses were inappropriate for generation of management advice for flyingfish. A length-based yield analysis based on the model of Thompson and Bell was conducted for the resources off Tobago and results suggested that the resource was at full exploitation. Additionally, in 1996, a CFRAMP Small Coastal Pelagic and Flyingfish Sub-Project Specification Workshop also addressed issues related to data collection, assessment and management. Based on results of genetic studies, countries agreed that the resource should be assessed and managed as a unit stock within the Eastern Caribbean.

Following the a presentation overview of the past work completed on the species and the situation regarding assessment and management activities, clarification was sought regarding the plans for the next meeting of the WECAFC Ad Hoc Working Group. The meeting was informed that it was not possible to confirm at this time that the WECAFC Ad Hoc Working Group on Flyingfish meeting would take place as planned. Additionally, the meeting was reminded that following the

Second Meeting of the WECAFC Ad Hoc Working Group on Flyingfish, countries were requested to undertake certain tasks; hence it was necessary for countries to complete the assigned tasks prior to a new assessment being attempted.

7.4.3 General issues discussed under item 7.4, with emphasis on data sharing

There was some discussion regarding data sharing by countries, and the sensitivities associated with this. It was noted a scientific committee could help the process of data submission, as it would have formal attachment to the CRFM. However, it was argued that working group chairpersons and rapporteurs were acting in a specific capacity on behalf of the CRFM, and that the present arrangement should not hamper data submissions. However, the meeting was reminded that despite the CRFM Agreement and the measures of collaboration it supported, countries were often negotiating with and against each other on various issues, and that it was natural to expect countries to be sensitive about sharing data. The meeting was informed that when a similar grouping of countries in West Africa dealt with this problem, they took a decision to establish a regional database; the existence of this database has now eliminated the problem of data sharing that was previously experienced. The meeting was also further informed that in the case of ICCAT, a similar problem was encountered during the 1960s. The matter was resolved when a scientific committee was assigned the task of defining the data requirements to facilitate the stock assessments. The list of data requirements was then used to develop a formal legal agreement. Having noted this, it was also pointed out that ICCAT data requirements had evolved over time.

The meeting was reminded that the Common Fisheries Policy initiative has been giving some treatment to data. However, the need to outline the problem to senior managers and to list the data needs to inform policy and legislation was clear. A small group was then given the task of drafting an appropriate recommendation in respect of the essential data and information reporting needs for stock assessments during the scientific meetings. It was pointed out that the task of determining the data needs would best be handled by the Ad Hoc Methods Working Group. However, given the importance of notifying the Forum formally of these reporting needs, it was agreed that the Secretariat would prepare an initial draft outline that would have to be circulated to countries for feedback prior to submission to the Forum. The Ad Hoc

Methods Working Group would be able to review and revise the data and information reporting needs, as deemed necessary.

7.4.4 Recommendations on data sharing and data reporting

The agreed concluding statement and recommendation in respect of data sharing and reporting needs follow:

Given the shared nature of most of the stocks to be assessed and the consequent need for utilizing stock assessment data from more than one country, the Meeting reiterated the need for a formal data sharing mechanism that would allow for the provision of the data necessary for carrying out these assessments. The meeting recommended that, to facilitate this data sharing, the type of data, and its minimum level of detail and disaggregation should be determined by the scientists responsible for carrying out the assessments and submitted to the Forum and Ministerial Council for approval. Pursuant to this, these minimum data requirements should be kept under review and revised as necessary. It is noted that implicit in the above is the necessity of documenting the manner in which the data are collected (i.e. the sampling design) and processed.

7.5 Large Pelagic Fish Resource Working Group (LPWG)

The report of this Working Group is given in Appendix 7.

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

Following presentation of the report, the representative from NMFS SEFSC (and the current chairman of ICCAT's Standing Committee on Research and Statistics) expressed his hope that the recommendations, in respect of increased participation in ICCAT, would be implemented.

In terms of technical questions, the Working Group was cautioned about equating the point $F_{20\%\ SPR}$ as a 'safe' level and referring to it as 'acceptable'; in the present context it was suggested that the report should indicate that the point $F_{20\%\ SPR}$ was a threshold above which the risk of further stock decline was high. The reference of $F_{30\text{-}35\%SPR}$ is now more commonly used as a limit reference point in the USA, which implies a lower level of fishing pressure.

It was pointed out that the uncertainty in the growth parameters affected the confidence with which management advice can be provided. The meeting was then 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 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 should be explored further.

There was then a lengthy discussion about the fact that the report did not indicate if one of the models was better, and so the management advice was unclear. It was argued that the report did not provide sufficient advice for guiding managers. It was also suggested that the scientists should consider what managers could relate to more easily, and what managers would find acceptable to work with. The meeting was reminded that within the CRFM States, it was often the case that scientists played at least some role in management decision-making, and so it would be useful if the reports could extend their logical arguments to give more precise guidance to managers. However, it was argued that scientists and managers have specific roles, and that managers need to consider the advice as given, and take their decision within the wider context that would need to take into account socio-economic and other factors.

Given the obvious level of uncertainty, some participants questioned the readiness to provide management advice on this resource. In response, the consultant emphasized that the sample size used was small, and hence it was necessary to be careful about making stronger, more specific recommendations at this time. However, the present report indicated that the problem was sufficient to be a concern, and that managers should give urgent attention to the collection of more data on this fishery in the immediate future. The meeting was informed that in other parts of the world such as the USA, managers made use of decision tables to help resolve issues of uncertainty. Having noted this, there was often difficulty recognizing the actual decision that was needed. Given that consideration of socio-economic information was emphasized in earlier discussions, it was recommended that the present forum should consider applying a decision table format. The meeting was reminded of the multispecies nature of the fishery concerned and possible complications of implementing measures that would impact on other major target species taken.

Several persons observed that the report was too technical; it was necessary to simplify the language and shorten the report. Appropriate changes were made to the report in reaching the final version now included in Appendix 7.

7.5.2 The dolphinfish (*Coryphaena hippurus*) fishery
The Working Group was asked whether the trend in landings had been examined, as it was good to consider the trends in both the CPUE and landings simultaneously. The importance of the recommendation to obtain information on the different fleets was highlighted. It was pointed out that the report structure could be improved, and that some explanatory text was needed to explain the figures more clearly.

7.5.3 General issues discussed under item 7.5
Clarification was sought on the recommendation to form a scientific committee, to inform the discussion of this topic under agenda item 11. It was explained, using specific situations, that the scientific committee would allow the activities of the Working Group to be more organized and formally structured. The meeting was informed of a GLOBEC initiative to develop an information base of the world's fish resources, and it was thought that it could be useful for the Working Group to establish linkages with this initiative.

The need to coordinate management of shared resources was again clear in this case, as it was in the case of other Working Groups. A query was raised regarding the possibility of ICCAT delegating some resource management responsibilities to the CRFM. Additionally, confirmation was sought regarding the management of the king mackerel fishery by the US councils (as indicated in the king mackerel report). In response, it was clarified that the US management plans cover only the marine zones belonging to the USA. The meeting was also advised that there was a good opportunity for the CRFM to lead the process of assessment and management for the small tuna resources found in the CRFM region and to gain acceptability by ICCAT of the information content prepared and considered within the present forum. The meeting recommended that mechanisms be put in place to pursue the coordinated management of the resources concerned.

8. Special lecture

8.1 Promotion of the FMSP Fishery Management and Stock Assessment Guides

The presentation was well received, with several participants noting the usefulness of the presentation and the guides. It was recognized that some goals can be conflicting and hence there is always a need to reach compromises in order to achieve a balance. Moreover, goals tend to change with time, and hence it was necessary to plan properly to ensure timely responses to evolving needs.

9. Identification of assessment priority needs for 2007 period

9.1. RSWG

The meeting attempted to identify the assessment priority needs for each of the fisheries working groups. Given that reef and slope fisheries were important to numerous CRFM States, officers were asked to remind the meeting of those fisheries which were commercially important and for which management concerns had been identified. Of course, the species of interest varied with the State (list of priority species proposed by fisheries officers on behalf of their countries is given in Appendix 8). Based on the information provided, the species most commonly important was the red hind (*Epinephelus guttatus*). The meeting was also reminded of fisheries managers' concerns in Jamaica regarding the state of reef fisheries there, and particular concern in respect of the parrotfishes (Family Scaridae). Reef fish resources were also heavily exploited in the Turks and Caicos Islands. Both in Jamaica and in the Turks and Caicos Islands, lack of resources hindered the routine collection of data needed to evaluate these fisheries. In view of this, it was pointed out that the reef and slope fisheries could be good candidate fisheries for applying the Ecological Risk Assessment Method. In the final analysis, four reef and slope fish species {mutton snapper (*Lutjanus analis*), red hind (*Epinephelus guttatus*), lane snapper (*L. synagris*), and Nassau grouper (*E. striatus*)} were noted for assessment in 2007, based on the identified needs of the country from which the rapporteur was selected, and the possibility that this would provide for testing application of the Ecological Risk Assessment method to CRFM situations.

9.2. CLWG

The meeting was reminded that this Working Group had proposed to examine data from all queen conch (*Strombus gigas*) and spiny lobster (*Panulirus argus*) fisheries within CRFM States in 2007. Given this, the countries involved in these fisheries were identified. The importance of obtaining data from all fishing states, including the French and Dutch Islands, was emphasized. States claiming to have less important fisheries, such as Tobago and Montserrat, were urged to submit their data for incorporation into the planned 207 assessments. There was also some discussion about the popular use of visual surveys for evaluating the status of queen conch stocks within CRFM States. However, it was argued that a single method may not be appropriate for all countries. It was important to consider the reliability of assessments, and the Methods Working Group was best placed to consider the arguments in respect of the suitability of any particular method.

In the final analysis, four major fisheries were listed to be assessed (see table in section 10), although data from all fishing States would be used to attempt construction of a more regional picture of the status of the two resources noted.

9.3. SGWG

The meeting was reminded that this Working Group proposed to apply a similar analysis to the Guyana and Suriname shrimp fisheries, as completed for the Trinidad and Tobago and Venezuela fisheries during the present meeting. Data on the five shrimp species (see table in section 10) would be required to facilitate this.

In respect of priorities for groundfish assessments, the Working Groups proposed that the three species from the 2006 list be retained {lane snapper (*L. synagris*), bangamary (*Macrodon ancylodon*), and sea trout (*Cynoscion virescens*)}, given that two of the three planned assessments were not undertaken during the present meeting. Additionally, the Working Group proposed that the following two species be added to the list for 2007: red snapper (*L. purpureus*) and whitemouth croaker (*Micropogonias furnieri*).

9.4 LPWG

The Working Group noted the possibility that additional dolphinfish (*Coryphaena hippurus*) data from the region could be made available in the near future. If these data become available, it should provide an opportunity to improve the analysis in 2007; noting this, and given the importance of this fishery to several Eastern Caribbean territories, dolphinfish was identified to be examined again in 2007. The Working Group also proposed that wahoo (*Acanthocybium solandri*) be included in next year's list, but advised that the proposed assessment should be handled by the ICCAT SCRS. The meeting was advised of ICCAT's developing interest in evaluating the status of wahoo, and the fact that this would provide an opportunity to solicit the support and participation from other scientists at ICCAT in completing the proposed assessment. The meeting agreed that the available data from CRFM fishing States should be compiled and submitted to the ICCAT SCRS in time. Additionally, it was recommended that a CRFM scientist (selected from an ICCAT Member State) should plan to participate in the ICCAT SCRS meeting in 2006, and collaborate with other ICCAT scientists to complete the wahoo fishery assessment. The meeting was reminded that there was now good growth information available on wahoo from the IMA; it was confirmed that this information would be made available to facilitate the wahoo assessment.

The Working Group also proposed the inclusion of king mackerel and Spanish mackerel for 2007, in the event that new data become available to improve the evaluations by the time of the next scientific meeting. It was also proposed to include Crevalle jack (*Caranx hippos*), given that this species was taken as a bycatch in the large pelagic fisheries of Trinidad and Tobago that harvested the mackerels. A query was raised about the importance of considering blackfin tuna given the importance of this species to many Eastern Caribbean States. In response, it was noted that ICCAT would probably be the best forum to conduct the blackfin tuna assessment. However, this species was not receiving sufficient interest in ICCAT at this time. The meeting was advised that country summaries indicating the importance of blackfin tuna should be presented to ICCAT to support arguments for attempting an assessment in the near future. Additionally, it was suggested that data on blackfin tuna fisheries should be compiled in preparation for an assessment in 2-3 years.

9.5 General issues

The meeting was informed of further potential for assistance and training in assessment analyses through a recent ICCAT initiative aimed at developing data collection and analysis capacity in Developing States that were Contracting Parties to ICCAT. Some of the recommendations made by the Methods Working Group could be addressed using this option. Of course, it would be necessary to submit a written proposal to ICCAT. Both Trinidad and Tobago and Barbados expressed their interest in formulating the required proposal for submission to ICCAT.

The importance of gathering data from all fishing States was emphasized. The meeting was also advised of planned WECAFC meetings aimed at examining the red snapper fisheries. There was no confirmation on the timing of the planned WECAFC activities.

9.6 Recommendations:

(i) The meeting recommended that CRFM States that were also members of ICCAT should seek to participate fully in ICCAT SCRS activities.
(ii) The meeting recommended that the relevant rapporteurs from Trinidad and Tobago and Barbados collaborate to develop and submit a written proposal requesting ICCAT assistance to address the training needs identified by the Ad Hoc Working Group on Methods.

10. Selection of Working Group Chairpersons and Species Rapporteurs for 2007 period

Working Group	Chairperson (and Co-Chair, if elected)	Species assessments (proposed preliminary list for 2007)	Rapporteurs and allocated assessment responsibility for 2007
RSWG	Ramon Carcamo	(i) *L. analis* (mutton snapper), (ii) *Epinephelus guttatus* (red hind) (iii) *E. striatus* (Nassau Grouper) (iv) *Lutjanus synagris* (Lane snapper)	(i) to (iv) Ramon Carcamo
CLWG	Lester Gittens	*Strombus gigas* (queen conch) Stocks of (i) The Bahamas, (ii) Jamaica, and (iii) The Turks and Caicos Islands (iv) St. Lucia	(i) Lester Gittens (ii) June Masters (iii) Kathy Lockhart (iv) Patricia Hubert
		Panulirus argus (spiny lobster). Stocks of (v) The Bahamas (vi) Jamaica (vii) Turks and Caicos Islands (viii) St. Lucia	(v) Lester Gittens (vi) June Masters (vii) Kathy Lockhart (viii) Patricia Hubert
SGWG	Suzette Soomai	(i) *Farfantepenaeus notialis* (southern pink shrimp), (ii) *Xiphopenaeus kroyeri* (Atlantic seabob), (iii) *F. subtilis* (southern brown shrimp), (iv) *F. brasiliensis* (redspotted shrimp) (v) *Litopenaeus schmitti* (southern white shrimp)	(i) to (v) Rapporteur(s) from Guyana and/or Suriname to be selected
		(vi) *Lutjanus synagris* (lane snapper) (vii) *Macrodon ancylodon* (bangamary) (viii) *Cynoscion virescens* (sea trout) (ix) *Micropogonias furnieri* (whitemouth croaker)	(vi) to (ix) Suzette Soomai (Trinidad and Tobago fisheries), & Rapporteur(s) to be selected from Guyana and/or Suriname (Guyana and Suriname fisheries)
SCPWG	Crafton Isaac	(i) *Hirundichthys affinis* (fourwing flyingfish) (ii) Others to be determined, based on data quality and availability	(i) Rapporteur to be determined; (ii) Crafton Isaac
LPWG	Christopher Parker	(i) *Coryphaena hippurus* (dolphinfish) (ii) *Acanthocybium solandri* (Wahoo)	(i) & (ii) Christopher Parker

		(iii) *Scomberomorus cavalla* (king mackerel)	(iii) Louanna Martin
		(iv) *Caranx hippos* (Crevalle jack)	(iv) Elizabeth Mohammed

10.1 General issues

Noting the concern by some countries regarding the naming of specific representatives for the Scientific Meetings, it was suggested and agreed that the CRFM Secretariat would write to the countries concerned soon after the meeting, advising of the selections and seeking a reconfirmation of the agreed arrangements for the selected officers to serve in the capacities identified.

A query was raised regarding the possibility of permitting more than one rapporteur from a single country. It was clarified that this was possible in theory. The choice of rapporteurs depended on the priorities identified. However, the meeting was advised that the Secretariat could approach a country to provide funding for the additional rapporteurs whenever this occurred.

Another query was raised with respect to the need for holding meetings on an annual basis. In response, it was pointed out that the annual meetings help to ease the burden of assessment work by facilitating assessments of each species to be completed on a rotational basis, i.e. some species could be assessed every 2-3 years, allowing other species to be assessed in the intervening years. The 2-3 year gap for any particular assessment would then permit sufficient time for additional data collection and research needed to improve the assessments when repeated. The rotation of assessments also allowed the Scientific Meeting to address the varied needs of all Member States concerned. Recognising the natural fluctuations in fish stocks, and the generally increasing trend in fishing pressure in the region, holding assessments at a frequency of less than every 2-3 years would be neither precautionary nor responsible. Given the numbers of species for which management advice is required, and the capacity limitations both in country and in the CRFM, both annual meetings and coordinated inter-sessional work are necessary to provide management advice and ensure that national fishery goals are met.

11. Any other business

11.1 Urgent Requirements of the Ad Hoc Working Group on Methods

An endorsement was sought and obtained for recruiting the Ecological Risk Assessment expert to be made available for the next meeting of the Ad Hoc Working Group on Methods.

The meeting was also advised of data collection needs to facilitate testing of those methods which were more applicable to limited data situations. These methods would require certain types of data that could be collected in the short term. However, to facilitate timely collection of the necessary data, countries would have to begin the collection process immediately following completion of the next meeting of the Ad Hoc Working Group.

11.1.1 Recommendation

The meeting endorsed the immediate pursuit of the data collection activities to facilitate the testing of methods useful for application in limited data situations, and which would be identified during the Second Meeting of the Ad Hoc Working Group on Methods.

11.2 Formulation of a Data Policy

The formulation of a data policy was suggested for consideration in light of the fact that at CRFM Scientific Meetings data are commonly and widely shared (regional and international). Based on previous discussions on data sharing, as well as recommendations of the Ad Hoc Working Group on Methods, and perhaps more specifically the development of a centralized repository for regional fisheries data and information, a general data policy was considered essential. In addition to the recommendation proposed in section 7.4.3, the data policy could address other issues e.g., data ownership as well as the terms and conditions of data use and dissemination. It was noted that the issues and data policy idea were not new to the region. It was pointed out that the regional FAO project titled "Scientific Basis for Ecosystem-Based Management in the Lesser Antilles, including interactions with marine mammals and other top predators", commonly called the Lesser Antilles Pelagic Ecosystem Project (LAPE), formulated a data policy to govern the use and dissemination of information collected and generated by the Project. It was proposed that the associated LAPE document could be used as a guide in preparing a draft data policy for consideration and eventual endorsement by countries.

11.2.1 Recommendation

The meeting acknowledged that the Common Fisheries Policy, that was currently being formulated, included a component dealing with data. The meeting agreed to examine the FAO LAPE Policy document as a potential useful reference document for informing the further development of the data policy component of the Common Fisheries Policy.

11.3 Establishment of a Scientific Committee

It was argued that the rationale for a scientific committee rests heavily on the need to organize and gain formal recognition as a body within the CRFM. Such formal status and recognition would also facilitate networking with other scientific fora, while ensuring that CRFM scientific inputs are given their due acknowledgement.

It was proposed that the scientific committee could be responsible for overseeing, *inter alia*:

(i) management and documentation of assessment methodologies used;
(ii) the formal body that reports directly to the Caribbean Fisheries Forum;
(iii) advising Working Groups on data requirements and providing quality control for the outputs of the Working Groups;
(iv) maintenance of datasets used for assessments;
(v) instructions for data submission for assessments;
(vi) networking with other scientific fora;
(vii) training in data analysis and assessment, and report writing;
(viii) scientific publications of the committee;
(ix) ensuring broader participation in committee activities by all countries in the region of concern

Given the need for data and information from the full range of the distribution of shared resources, it was also proposed that consideration be given to not restricting membership in the scientific committee to just CRFM member states, but all range states and fishing states involved in the fisheries.

While the meeting appreciated the value and logic for this proposal, it covered several very important issues that would require more detailed consideration. The meeting was also informed that the status of the technical Working Groups was unclear at this time. It was suggested that a proposal could be drafted for review by the meeting in the future.

11.3.1 Recommendation
The meeting recommended that a proposal for the establishment of a Scientific Committee be developed for presentation and consideration during the next Scientific Meeting.

11.4 Format of Fishery Reports

It was suggested that it would be useful to include in the reports a table showing the species relative importance to each country. In response, it was noted that there were numerous species caught by the countries, but perhaps the table could be prepared for the more important species.

It was also pointed out that while the reports had the same table of contents, the content itself varied somewhat with the report. The meeting was reminded that a report format, with guidelines, had been developed during the First Scientific Meeting. However, practice would help to make reports more consistent in the future. The management summaries for lane snapper and for dolphinfish were considered to be good examples of well-prepared management summaries. However, the lane snapper report could be improved by inclusion of a graph.

11.5 ECOST Project Update

It was pointed out that outputs of the reef fishery study being conducted in Trinidad and Tobago should be considered in planning and decision-making. Hence, it was important to report the outputs of the ECOST project to the Scientific and Forum Meetings.

12. Review and adoption of meeting report

Some of the earlier sections of the plenary report were reviewed and several corrections were made. The meeting agreed on deadlines for submission of fisheries management summaries and detailed fisheries reports. It was agreed that the report would be adopted by e-mail.

13. Adjournment

The Chairman acknowledged the efforts of the Working Group chairpersons and rapporteurs to produce reports of excellent quality. He noted that the next scientific meeting would be enriched by the present experiences. The Chairman also expressed his hope that Working Group chairpersons and rapporteurs would improve their collaboration during the inter-sessional period, and he reminded them of the availability of internet telephony programmes such as ‘Skype’ that could greatly assist the process. The persistent efforts and interest demonstrated by the consultants and other assessment experts were also acknowledged. The Chairman noted his appreciation of the interventions provided by all participants to ensure a successful meeting, including those made by representatives from the OECS Secretariat, UWI, NOAA, FAO, JICA and IMA. He also took the opportunity to thank the CRFM Programme Manager responsible for Research and Resource Assessment for her vision and work in implementing this initiative. Finally, the Chairman thanked the government of Trinidad and Tobago for the substantial and highly professional support provided by Ministry officials during the meeting.

The meeting was adjourned at about 5.00 p.m.

References

Manickchand-Dass, S. (1987). Reproduction, age and growth of the lane snapper, *Lutjanus synagris* (Linnaeus), in Trinidad, West Indies. *Bulletin of Marine Science,* Vol. **40**, No. 1: 22-28 p.

APPENDICES

Appendix 1: Agenda

CRFM ANNUAL SCIENTIFIC MEETING

(*Cascadia Hotel and Conference Centre, Port of Spain, Trinidad and Tobago, 13-22 March 2006*)

MEETING AGENDA

Individual Working Group Sessions: 13th – 18th March 2006

Completion of selected fisheries analyses and assessments and Working Group reports

Formal plenary sessions: 20th – 22nd March 2006

1. Opening of the meeting.
2. Election of chairperson.
3. Adoption of meeting agenda and meeting arrangements.
4. Introduction of participants.
5. Review of national (country) reports.
6. Review of Report of the First Meeting of the CRFM Ad Hoc Working Group on Methods.
7. 2005-2006 reports of the CRFM Fisheries Working Groups:
Reef and Slope Fish Resource Working Group (RSWG);
Conch and Lobster Resource Working Group (CLWG);
Shrimp and Groundfish Working Group (SGWG);
Small Coastal Pelagic Fish Resource Working Group (SCPWG);
Large Pelagic Fish Resource Working Group (LPWG).
8. Special lectures: Recent efforts by DFID's (UK Department for International Development) FMSP (Fisheries Management Science Programme) to develop fishery manager's and scientist's stock assessment guides suitable for use by developing countries.
9. Identification of assessment priority needs for 2006-07 period.
10. Selection of Working Group Chairpersons and Species Rapporteurs for 2006-07 period.
11. Any other business: urgent requirements of the Ad Hoc Working Group on Methods; formulation of a data policy; establishment of a Scientific Committee; ECOST project update.
12. Review and adoption of meeting report.
13. Adjournment.

Appendix 2: List of Participants

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Appendix 3: Revised Terms of Reference for the Ad Hoc CRFM Working Group on Methods, adopted by the present meeting

Background and Rationale

CRFM objectives include, *inter alia*: the efficient management and sustainable development of marine and other living aquatic resources within the jurisdictions of Member States; and the provision of technical advisory and consultative services to fisheries divisions of Member States in the development, management, wise use, and conservation of their marine and other living aquatic resources. Pursuant to these objectives, the Caribbean Fisheries Forum (CFF), during its first annual session in 2003, endorsed the establishment of five fish resource working groups, for the purpose of coordinating fisheries assessment activities at the regional level and the provision of advice to inform planning and decision-making in respect of fisheries development, management and conservation issues.

In view of the present limited financial resources and assessment skills within CRFM States, and having recognized the need to regularize and broaden regional evaluation of the work completed by each of the groups concerned, the CRFM held its first annual scientific meeting in 2004. This forum was essentially a joint meeting of all CRFM fish resource working groups, and also facilitated useful discussion on issues of common concern to all the working groups, such as data quality and the appropriate application of various assessment tools to the management situation within CRFM States.

During the 2004 scientific meeting, participants acknowledged the importance of optimizing the usage of the various types, amounts and quality of data usually gathered and made available within CRFM States. Noting that it was often not possible for fisheries staff within CRFM States to apply the more conventional assessment methods requiring high quality, reliable, and detailed data, meeting participants recommended the establishment of an Ad Hoc Working Group on Methods, to devote specific attention to developing and testing assessment methods, which could be more widely applied to data-poor situations and also which make better use of the types and quality of data collected by CRFM countries.

Terms of Reference

Consistent with the recommendations of the First Annual CRFM Scientific Meeting, an Ad Hoc Working Group on Methods is established with agreed terms of reference as follows:

1) Review current management advice needs and constraints within CRFM countries.
2) Develop recommendations to improve communications between scientists and managers.
3) Conduct a comprehensive review of resource and fisheries assessment methodology, with emphasis on those methods suitable for application to Caribbean fisheries. This will involve presentation of software tools, with examples of applications.
4) Based on review noted in (3), select those tools considered most useful for providing immediate contributions to the fisheries management process within the CRFM region.
5) Develop and apply criteria for evaluating the performance and suitability of the tools examined. Possible evaluation criteria include:
   a) Scientific accuracy and validity of the method;
   b) Ability of tools to incorporate uncertainty and provide advice on risks;
   c) Data requirements and the ease of collecting such data;
   d) Skills required by users;
   e) The accessibility and availability of these skills within the region;

f) Level of usage of tools by fisheries officers and scientists within CRFM countries (or ease of presentation and understanding of the concepts/ reference points/ outputs);
g) Advancement of the management process, i.e. level of understanding and usage by management groups.
h) Ability of the method to provide advice based on the goals of management.

6) Test selected software tools using simulated and real data from CRFM countries.
7) Develop recommendations for applying assessment tools to specific fisheries management situations within CRFM countries.
8) Consider and pursue additional tasks pertaining to development and application of appropriate assessment methods, as appropriate.
9) Develop practical recommendations to improve data collection for successful implementation of approved assessment methods.
10) Document findings in meeting reports, and present findings to the Annual CRFM Scientific Meetings.

Mode of Operation

The CRFM Secretariat will be responsible for coordinating the activities of the Working Group.
The Working Group, through the CRFM Secretariat, should work closely with staff of national and regional institutions, and of regional organizations such as FAO (WECAFC) and OECS, in order to make full use of available technical expertise. The CRFM will ensure collaboration with non-CRFM countries to secure the inclusion of their inputs.

Additionally, the Working Group may establish smaller working groups to undertake specific tasks that require extra attention, and that are considered essential for the production of successful and acceptable outputs.

Membership of the Working Group & Participation

CRFM Member countries are members of the Ad Hoc Working Group on Methods and will be responsible for ensuring implementation of agreed Working Group recommendations at the national levels. It is essential that rapporteurs of CRFM Resource Working Groups participate in the activities of the Working Group.

Other scientific representatives from CRFM countries will also be invited to participate at their own expense. Fisheries staff in territories adjacent to CRFM Member countries, fisheries staff of regional organizations such as FAO, and OECS, fisheries staff of research institutions such as UWI, will be invited, at their own expense, to participate in meetings of the Working Group. Working Group meetings can take place given the presence of at least six different country representatives. A Chairperson, Vice-Chairperson, and Rapporteur should be elected, as required.

Working Group Meetings

An on-site meeting of the Working Group should be convened once every year during the period 2005-2007. Following this period, the progress and continued need for the Working Group will be reviewed and its terms of reference updated and renewed, if necessary.

Appendix 4: Recommendations of the First Meeting of the CRFM Ad Hoc Working Group on Methods that received endorsement during the present meeting

1. Recommendations made by Smaller Working Group on Communications

i. Request those countries which have not yet submitted manager's questionnaires to submit.
ii. Provide feedback on submitted questionnaires, including attempts made to unpack Trinidad case study and problems found, and request countries to comment on observations and working group objectives.
iii. Prior to the next WG meeting, request Trinidad participants to continue case study as far as operational objectives, for further evaluation of stock assessment methods and management measures at next WG (for further feedback to managers).
iv. Considering the incongruity between management ambitions, the data actually available within the region, and fisheries departments' capacity for future data collection, ensure that any unpacking or management process is realistic and feasible.
v. Recognizing that the CRFM already conducts national consultations, which take place when countries are ready to review their fisheries management plans, use the CRFM national consultations to enhance the process by which managers and stakeholders review and refine their management objectives.
vi. Consider undertaking an analytical hierarchical process, involving interviews, weighting interpretations, and engaging in manager-stakeholder consultations to determine the priorities.
vii. Complete the process of refining management objectives at both the national and regional levels.

2. Recommendations made by Smaller Working Group on Data

i. Develop an inventory of data availability.
ii. Develop a framework for harmonized sampling programmes taking into account the minimum biological sampling required to enable characterization of the composition of important fishery catches, and for establishment of a centralized repository for shared fisheries data and information.
iii. Develop a regional database of life history parameters for crustaceans, and possibly also for finfish if not already covered in FISHBASE.
iv. In cases of limited catch and effort data sets, make available any auxiliary data (e.g. local consumption surveys and other market data; transshipment data) for incorporation into assessments. Additionally, where possible, length frequency data could be collected for at least one year, so as to combine these data with the limited catch and effort data to indicate the state of the stock.
v. Recognizing the importance of socio-economic considerations, and noting the availability of certain social and economic data, recruit someone specialized in socio-economic analyses to advise the Working Group.
vi. Develop criteria for selecting methods.
vii. Consider and implement options for building staff skills, ensuring a sound foundation before advanced techniques are taught. All staff should be comfortable with using advanced features in MS Excel and receive training in data management and manipulation in EXCEL if

necessary. This training will allow for more efficient and quicker conduct of analyses since the fisheries scientists will be better able to understand their data sets and the use of data in developing indices for fisheries monitoring. It was recommended that the countries would benefit most from immediate training in the use of Pivot Tables in EXCEL and Solver and in the methods used for standardizing CPUE.

3. General Recommendation

i. Invite an expert in application of the Ecological Risk Assessment method to the next meeting of the Ad Hoc Working Group.

Appendix 5: Report of the Conch and Lobster Resource Working Group

Chairman: Lester Gittens
Consultants: John Hoenig PhD, Paul Medley PhD
Rapporteurs: Lester Gittens (Bahamas), Patricia Hubert (St. Lucia), Kathy Lockhart (Turks and Caicos Islands), June Masters (Jamaica)

A. OVERVIEW

The Conch and Lobster Working Group meeting was attended by representatives of Jamaica, St. Lucia, the Bahamas and the Turks and Caicos Islands.

At the last meeting, it was recommended that the following stocks be reviewed:-

Bahamas:	conch and lobster
Turks and Caicos:	conch
St. Lucia:	lobster
Jamaica:	conch

These stocks were evaluated at this meeting.

For the next meeting, it is recommended that conch and lobster be reviewed for all countries that are a part of the working group because of widespread concern about the status of both conch and lobster fisheries within the Caribbean Basin.

The general recommendations of the group were:-

- Countries should review their commercial fishery data collection and analysis systems to ensure that the sampling design is appropriate, quality control procedures have been applied to the entire time series of data, and data processing methods are appropriate. Documentation of the data collection and handling process also need to be shared with consultants prior to meetings in order to facilitate their understanding of limitations of the data.

- Consultants needed for particular tasks should be identified and contracted early, and documents should be sent to the consultants, well in advance of meetings. Consultants should be encouraged to visit countries, where appropriate, when they travel to the assessment meetings. This is to facilitate consultants having a greater grasp of the quality of the data to be analyzed.

- An intraregional market analysis is needed to improve export statistics for conch. This is because of the possibility that export statistics from a given country may actually include conch that was previously imported and thus not a part of the conch produced from that country.

- A special meeting, or a portion of the methods meeting, should be devoted to issues of sampling design and data quality.

- Terms of Reference for the working group should be dictated by decision makers and/or managers of the fishery.

B. FISHERIES REPORTS

1. The spiny lobster (*Panulirus argus*) fishery of St. Lucia

At the first scientific meeting, held in St. Vincent, a decision was taken by the St. Lucia fisheries representative that our first assessment will be on the Spiny Lobster (*Panulirus argus*) fishery.

1.1 Management Objectives

The main management objective for this fishery is to ensure sustainable use of the stocks and to promote the development of the use of selective fishing gear and practises that minimise the capture of juveniles.

1.2 Status of Stock

The current status of the stocks is yet to be determined. Proper analysis of the status of the lobster stocks will be determined after thorough verification of the data entered into the program versus the hard copy data. Preliminary results suggest some stability in the fishery. Furthermore, the stock is protected by a large minimum size (9.5 cm carapace length), a closed season and a no-take marine reserve.

1.3 Management Advice

The following are recommendations based on the data that were presented for analysis.

Although the available data do not show an immediate problem with this fishery, the data are limited. The time series is short and the length-frequency data are old. Before a great deal of faith can be placed in the results of looking at the commercial catch statistics, they should be reviewed carefully.

- The commercial catch statistics should be examined carefully to see if quality control measures were implemented prior to the 2000 observations.
- The processing of the data to obtain totals (catch and effort) should be reviewed.
- A review of the sampling design and sample sizes should be undertaken.

1.4 Statistics and Research Recommendations

1.4.1. Data Quality

In addition to several years of catch data and annual length frequencies during the open season, Table 1 gives an indication of available data on spiny lobsters. After 1999, the collection of maturity data was terminated.

From 2000 to the present, all catch and effort data have been subjected to integrity checks both prior to and following data entry. Prior to data entry, data sheets are checked for errors and omissions with the data collectors, whilst subsequent to data entry into Trip Interview Programme (TIP), data are also validated and verified for errors and omissions.

Table 1. Summary of data collected on spiny lobsters from 1996 – 1999.

Biological data on spiny lobster landed	Maturity data on spiny lobster collected at sea
Carapace length (mm) Sex Weight (g) Presence of spermatophoric mass Condition (intact or eroded)	Carapace length (mm) Sex Weight (g) Presence of spematophoric mass Condition (intact or eroded) Presence of eggs (ovigerous) Status of eggs (orange or brown) Effort data (depth, number of pots hauled, soaked time, total catch)

1.4.2. Research

- Further verification of the data is required before estimates can be developed that are suitable for responding to management objectives.

- Assessment of the lobster stocks should be undertaken. This assessment should also include sublegal size lobsters.

1.5 Stock Assessment Summary

Maturity of spiny lobster in St. Lucia

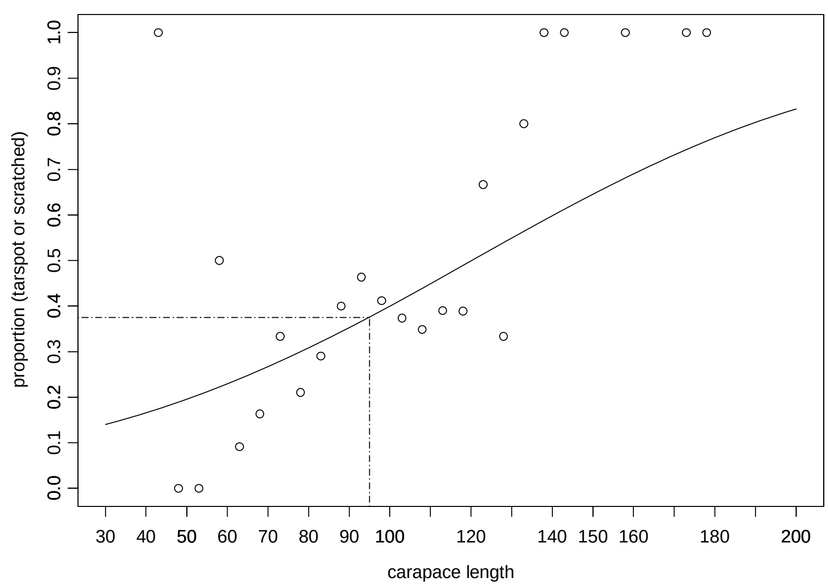


Figure 1. Proportion of lobsters with either a tar spot or a scratched tar spot as a function of carapace length (in mm). The fitted curve is a two-parameter logistic model.

Length-Maturity Relationship

Only mature females have tar spots or scratched tarspots. However, not all mature females will have a tarspot. Therefore, the percentage of females in a length class with tarspots (including scratched tarspots) is a minimal estimator of the percentage of females in the length class that are mature. The proportion of females with tarspots was plotted against carapace length (Figure 1). Sample sizes were greater than 30 animals for all length intervals from 68 to 118 mm cl. All but two of the remaining length classes had sample sizes of 5 or fewer animals.

A two-parameter logistic model was fitted to the data:

$$p(L) = \frac{e^{a+bL}}{1+e^{a+bL}}$$

where *p(L)* is the proportion with tarspots at length *L*, and *a* and *b* are regression coefficients to be estimated. The regression model was fitted using the logistic regression procedure in Splus. The parameter estimates were:

parameter	estimate	standard error	t-value
intercept, a	-2.41815851	0.407478366	-5.934446
slope, b	0.02011872	0.004179924	4.813177

Annual Lobster landings in St. Lucia

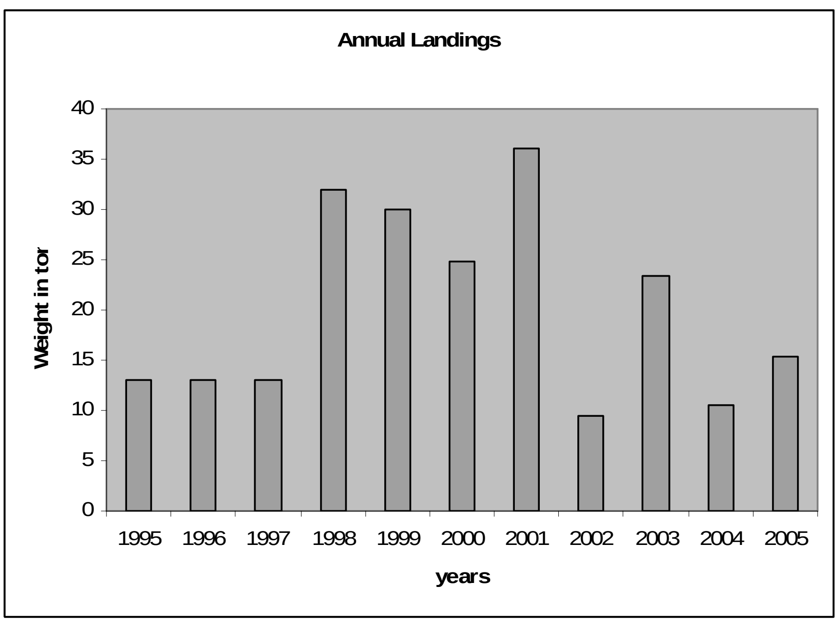


Figure 2. Annual landings are available from 1995 to 2005 (11 years) and have ranged from 13 tons to 37 tons with no apparent long-term trend. The average annual landings from 1995 to 2005 was 20 tons and the average landings over the last three years was 16 tons. Thus, from the perspective of landings, the fishery looks stable.

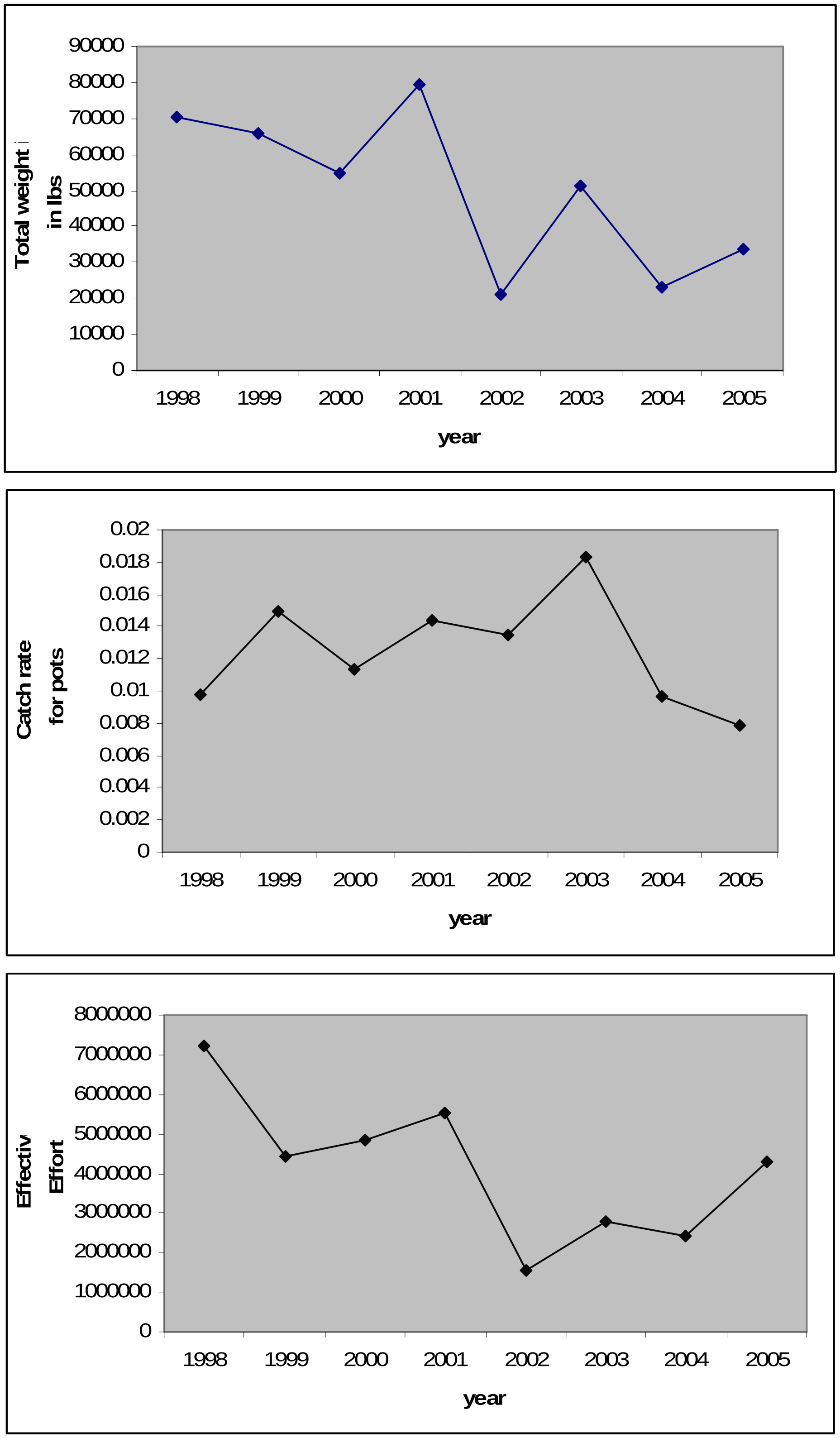


Figure 3. Statistics from the commercial fishery from 1998 to 2005. Top: total weight landed. Middle: catch rate from interviews of pot fishers. Bottom: effective effort.

Given that there were problems with the number or quality of the interviews conducted in 1995, 1996 and 1997, attention was focused on the period 1998 – 2005.

Effective effort was determined by dividing total landings by catch rate of pot fishers. This provides an estimate of the effort that would have been necessary to catch the total landings if all fishers used pots.

For the pot gear (which is the main fishing gear for lobsters in St. Lucia), effort is recorded in terms of hours of soak time, i.e., the number of days the pot was in the water. These data represent effort when recorded as 24 hours or above.

Overall these graphs show a somewhat stable lobster fishery. There is considerable year to year variation in the computed effective effort. This may be due to the fact that effort was derived from catch and catch rate information, rather than being estimated directly, and the catch rate data are variable. Also, the data need to be thoroughly reviewed for quality before the status of the fishery can be determined with confidence.

1.6 Special Comments

None.

1.7 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.
- Promote the development and use of selective fishing gear and practices that minimize by-catch of non-target species and the capture of juveniles.
- 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.

1.8 Scientific Assessments

1.8.1 Background or Description of the Fishery

The major fisheries resources of Saint Lucia comprise demersal, coastal pelagic and offshore pelagic fisheries. Although there is some year-to-year variability among these resources in terms of time, the fishing year of Saint Lucia can generally be divided into two main seasons: a “high’ season that extends from December to May when significant landings of offshore migratory pelagics occur and a “low” season that extends from June to November when relatively large quantities of demersal fishes are landed. However, the main “pot-fishing” season extends from June to February (Gobert & Domalian, 1995)

The offshore pelagic fisheries contributed 70% of the annual landings by weight which is made up of a number of migratory species including dolphinfish (*Coryphaena hippurus)*; mackerel (*Stromberomorus* spp*.)*; Wahoo (*Acanthocybium solandri)*; blackfin tuna (*Thunnus atlanticus)*; yellowfin tuna (*Thunnus albacares)*; Skipjack tuna (*Katsuwonus pelamis)*; sharks (various families); billfishes (Istiophoridae, Xiphiidae) and flying fish (*Hirundichthys affinis)* (Figure 4).

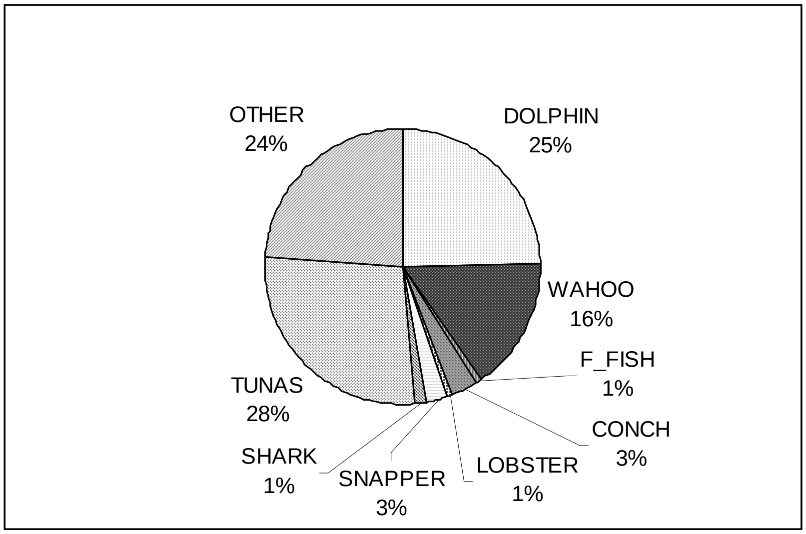


Figure 4: Percentage of landings for different families 2004.

In the coastal pelagic fishery, an array of species is targeted including: ballyhoo (Hemiramphidae spp.); barracudas (Sphyraenidae spp.); creole wrasse (*Clepticus parrae)*; herrings (Clupeidae spp.); jacks (Carangidae spp.); mackerels (*Decapterus macarellus)*; needlefishes (Belonidae spp.).

The demersal fishery lands are the most highly priced and valuable species for the local, tourism and export sectors including: snappers (Lutjanidae spp.); groupers (Serranidae spp.); Caribbean spiny lobster (*Panulirus argus)* and Caribbean queen conch (*Strombus gigas)*.

The Caribbean spiny lobster, *Panulirus argus,* is one of the most important single species fisheries in the nearshore of St. Lucia, second only to the conch fishery in terms of landings. However, its socio-economic importance is more wide scale than the conch fishery in which only 20 fishermen participate compared to several hundreds in the lobster fishery. *P. argus* is the most abundant and commercially important of the three *Panulirus* species (*P. argus, P. guttatus* and *P. laevicanda)*. However, *P. guttatus* is protected from commercial exploitation since it rarely attains the legal size limit of 95 mm. The majority of Caribbean lobster landings come from traps set in depths in excess of 30 m (Luckhurst & Auil-Marshalleck, 1995). Previously lobsters were fished with trammels nets, which are now banned from the island fishery; however, they are used illegally on a small scale. Caribbean spiny lobsters are also fished with spear guns by recreational fishers, although this practice is illegal.

The fishery for lobster sustains important artisanal fisheries during the "low[1]" fishing season. It is regulated with an eight-month fishing season, extending from 1st September to 1st May, inclusive. Yield has increased significantly over the past; although the extent of the increase is not reliably known

1.8.2 Overall Assessment Objectives

- The overall assessment objective was to determine:
- The changes in size frequency, size at first maturity and sex ration of Caribbean Spiny Lobster.
- What are the changes in relative abundance in the catch over time?
- What are the levels of recruitment to near shore habitats.

1.8.3. Data Used

Name	Description
Catch data	Observed lobster landings
Biological data	Female lobsters with tar spot
Total landings	Annual total lobster landings

1.8.4. Assessment 1

1.8.4.1 Objective

The landings and port sampling data were used to derive an estimate of effective effort. The results were plotted versus time to look at the stability of the fishery. Maturity data were evaluated to look at the degree to which the reproductive component of the female population may be protected by the minimum size regulation.

1.8.4.2 Method/Models/Data

Effective effort in terms of pots fished was estimated by the formula

Effective effort = landings / pot cpue.

A logistic model was fitted to the proportion of females with tar spots or scratched tar spots as a function of length. The model was

$$p(L) = \frac{e^{a+bL}}{1+e^{a+bL}}$$

where *p(L)* is the proportion with tarspots at length *L*, and *a* and *b* are regression coefficients to be estimated. The regression model was fitted using the logistic regression procedure in Splus.

1.8.4.3 Results

Annual landings over the last four years were close to the landings in the mid 1990s and slightly lower than the landings at the turn of the century (as shown in figure 2). Because there were problems with the number or quality of the interviews conducted in 1995, 1996 and 1997, attention was focussed on the period 1998 – 2005.

Over the period 1998 to 2005, catch rates were stable but landings declined. This implies a downward trend in fishing effort (as shown in figure 3).

[1] Traditionally the fishing year is divided into a "low" season and "high" season. During the high season mainly offshore pelagic species are targeted due to the availability during the low season, mainly demersal species are targeted (largely dependent on sea surface currents).

The parameter estimates from fitting the logistic model to the maturity (tar spot) data were

parameter	estimate	standard error	t-value
intercept, a	-2.41815851	0.407478366	-5.934446
slope, b	0.02011872	0.004179924	4.813177

The observed maturity data and fitted curve were shown in figure 1.

1.8.4.4 Discussion

The stable catch rates over the period 1998 to 2005 suggest a stable population. The concurrent downward trend in landings suggests a downward trend in fishing effort. Thus, the data do not suggest an immediate problem. However, data verification should be undertaken to determine if the downward trend in fishing effort is credible.

Approximately 38% of females at the minimum legal size (9.5 cm cl) have tar spots or scratched tar spots.

1.9 References

Gobert, B, and Domalain, G. (1995). Statistical analysis of St. Lucia (West Indies) 1990-1993. Document Scientifique du center ORSTOM de Brest, No. 77, Decembre 1995: 64 p.

Luckhurst, B and Auil-Marshalleck. (1995). Subproject Initiation Mission Report and Background Review for Spiny Lobster and Conch. *CFRAMP Research Document,* No. **17**: 54 p.

2. The Queen Conch (*Strombus gigas*) fishery of the Turks and Caicos Islands 2005/2006 Fishing Season

Rapporteur: Kathy Lockhart

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.
- To explore options of optimising economic earnings, including foreign exchange, from the queen conch fishery.
- To explore the feasibility of expanding markets for derivatives of conch (shells, trimmings, ornaments).
- To promote national and international collaboration in research and management in order to improve the effectiveness of managing the conch fishery of the Turks and Caicos Islands.

2.2 Status of Stocks

Although intensively fished and possibly over-fished in certain areas (Ninnes, 1994), the Queen Conch populations of the Turks and Caicos Islands are generally considered to be stable. It is assumed that unexploited 'deep-water' stocks exist that contribute significantly to recruitment of the fished stocks in shallower waters (Ninnes and Medley, 1995). The overall fishing effort under the current national annual export quota of 600,000 lbs. (272,160 kg) is considered to be maintaining the stock size at suitable levels (Anon., 1999). Studies on protected versus fished populations found differences in densities as well as age structure, with juveniles being significantly denser in fished areas than adults (Tewfik and Béné, 2003). For example, total densities in algal plains in fished areas were 687.2 conchs/ha versus densities of 2162 conchs/ha in protected areas. The overall mean density for both protected (EHLCR) and fished areas (Caicos and Turks Banks) was reported to be the highest in the region at 426.53 conchs/ha. According to the assessment conducted at the 2nd Scientific Meeting for CRFM, catch rates are operating at a constant level.

2.3 Management Advice

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

- Continue to assess the conch stock yearly, based on catch and effort data to determine an estimated sustainable yield (MSY).
- 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).
- Do not exceed current effort levels, because the current effort suggests that the fishery is operating within 88.1% of effort at MSY.
- Examine possibilities of hiring an economist to provide understanding of the economic pros and cons for the conch fishery.
- Aid in the development of a local niche market for conch derivatives in order to reduce processing waste and supplement resource users' net income.
- 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)

2.4 Statistics and Research Recommendations

2.4.1. Data Quality

Catch and effort data are collected from the local processing plants. The data is of good quality, but has a few areas of lacking information, such as illegal poaching. However, a visual survey is to be conducted before the end of 2006 to verify biomass levels are being estimated appropriately. The DECR has completed a local consumption survey of Queen conch and has incorporated it within the stock assessment.

2.4.2. Research

- Conduct a second visual survey to determine the abundance of conch before the end of 2006.
- Conduct research on size and length of conch before the end of 2006.
- Work with the Department of Economics and Planning to study economic aspects of the fishery before end of 2006.
- Produce projections for setting a quota at a percentage of the MSY before end of 2006.
- Fill the gaps of information for the TCI Queen Conch Fishery, such as tourist consumption. However, this is not a large priority, considering local consumption and estimated tourist consumption information did not greatly influence the assessment model (i.e. 0.1% more effective with local consumption information) (between 2007-2008).

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 produced that showed a high correlation of between 60 and 70% between observed and expected catch rates (CPUE). The model fits better when information on local consumption is added (figure 1). A decline in effort occurred during the 1980's when many of the fishers moved to the Bahamas for steady construction work.

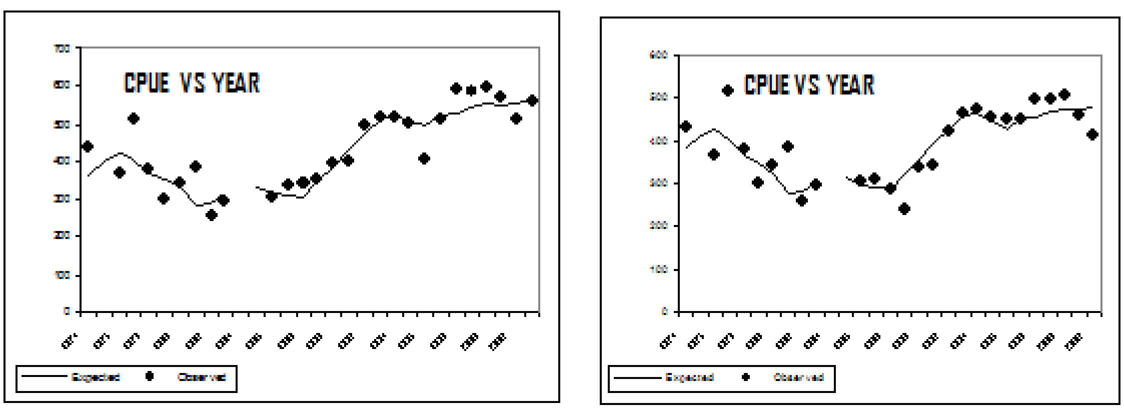


Figure 1. Observed vs. Expected CPUE for two models fitted using Excel's Solver. The model to the left has local consumption information added to the recorded catch while the model to the right does not include local consumption.

Stock Assessment Utilizing Local Consumption Data	Stock Assessment Utilizing ONLY Catch and Effort Data
p = 0.356777888	p = 0.43872712
r = 0.43641528	r = 0.39654584
K = 18674920	K = 17586991
q = 0.00005	q = 0.00005

Sum of Squares = 8.830E+11 Sum of Squares = 1.22E+12

The Schaefer model appears to fit the data well, and the data suggest that conch production is operating at or near optimum level.

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

Assessment (recorded catch & effort) only (1974-2003)	1,743,512 lbs. 3984.70 boat-days 54% 88.1%	MSY f_{MSY} B/B_{Vigrin} Effort as % of f_{MSY}	Quota for 2003-2004 1,587,227 lbs. 3511 boat days
Assessment (include local consumption) (1974-2003)	2,037,505 lbs. 3980.84 boat-days 54% 88.2%	MSY f_{MSY} B/B_{Vigrin} Effort as % of f_{MSY}	Quota for 2003-2004 1,972,233 lbs. (-400,000 lbs. local consumption) 3511 boat days

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 0.1% of the most conservative MSY. However, if the assessment is based on the addition of local consumption, the TCI government must remember that approximately 400,000 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

The TCI Government has an extensive collection of catch and effort data. However, there needs to be a verification of the stable stocks, since the model appears to indicate a fishery operating near the maximum sustainable level, which is not necessarily an optimum level. Within the next year, the DECR is to conduct another conch visual survey across the Caicos Bank to determine if the stock abundance is indeed near the level predicted by the model. It would also be reasonable for the TCI to conduct conch studies on size and weight to determine growth and mortality rates.

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. It is founded on the belief that all natural marine living resources of the TCI, as well as the environment in which they exist and in which mariculture/aquaculture activities may occur, are national assets and the heritage of all the people, and should be managed and developed for the benefit of present and future generations in the country.

The long-term vision of the Government of the TCI includes:

- Pursuance of well-informed strategic, economic and financial policies, which promote sustainable development and a decent standard of living for the people of the TCI.
- Achievement of greater functional and geographical diversification of economic activity, so as to reduce the TCI's economic vulnerability and to spread the benefits of economic growth more widely among its inhabitants.

- Implementation of policies and strategies to protect the interest of the TCI Islanders, thereby empowering them to derive optimum benefits from the development of the TCI.
- Initiation of measures contributing to the fusion of a dignified and confident nation at peace with itself and the world, a nation whose people believe in themselves and who, in their entrepreneurial, professional and other daily pursuits, and energized by dignity and national pride.
- Provision of sound health and educational services, which are available to all.
- To use our natural resources wisely, being fair to present and future generations.

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)

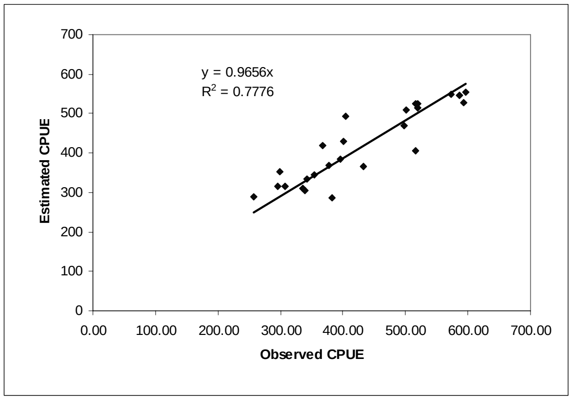
f = Effort of fishermen (in man-days)

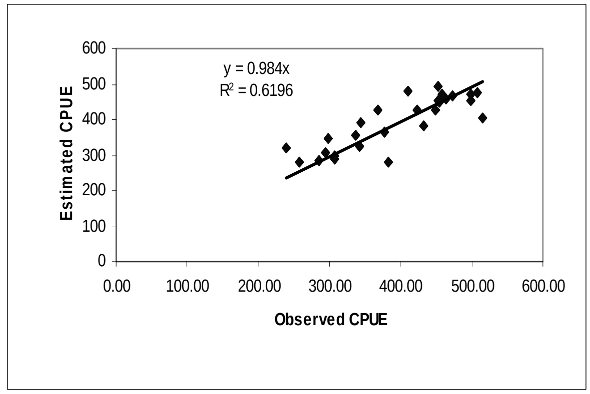
The Schaefer model utilized catch production. Population size allowed for an expected catch to be determined yearly. The expected catch divided by the effort produced an expected CPUE. The sum of squared errors is determined by comparing the expected and observed CPUE. The sum of squared errors is minimized 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 there was little difference (see figures 1 & 2).

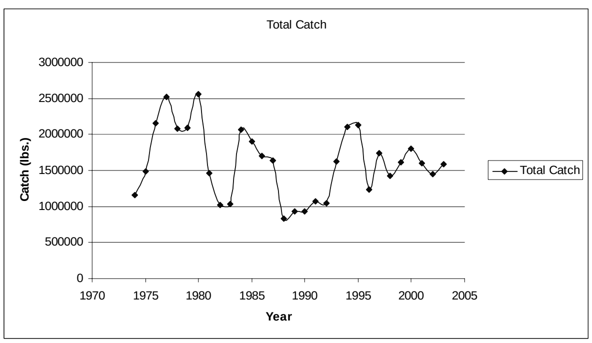




Correlation Utilizing Local Consumption Data

Correlation Utilizing ONLY Catch and Effort Data

Figure 2. Observed vs. expected CPUE with regression. Both models show a correlation (r^2) of approximately 70%.



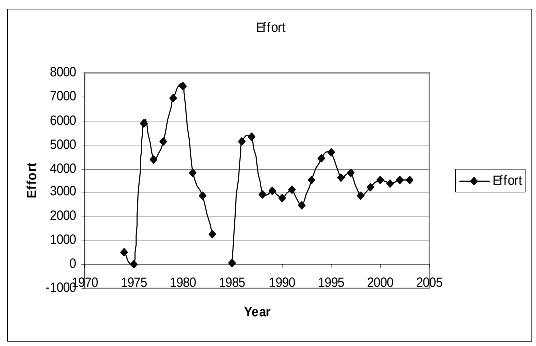


Figure 3. Catch and effort from 1974-2003. The above charts indicated that catch increased as effort increased.

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

Assessment with recorded catch & effort only	1,743,512 lbs. 3984.70 boat-days 54% 88.1%	MSY f_{MSY} B/B_{Vigrin} Effort as % of f_{MSY}	Quota for 2003-2004 1,587,227 lbs. 3511 boat days
Assessment with local consumption included in the catch	2,037,505 lbs. 3980.84 boat-days 54% 88.2%	MSY f_{MSY} B/B_{Vigrin} Effort as % of f_{MSY}	Quota for 2003-2004 1,972,233 lbs. (-400,000 lbs. local consumption) 3511 boat days

2.8.4.4 Discussion

The Turks and Caicos Islands conduct an assessment for conch every year. However, this forum allowed finding discrepancies in the data that have now been correctly assessed. During this forum the TCI investigated a Schaefer model that fits the data well and that provides estimates of MSY, the effort required to obtain MSY, size of the population relative to the virgin population size and the size producing MSY, and the current fishing effort in relation to the effort producing MSY.

During the assessment, the TCI also investigated the effects of having unknown landings (i.e. local consumption). A survey was conducted in 2004-2005 on the local population to determine a local consumption index. This information was then added to the catch data that is collected via commercial landings (at processing plants) and the Schaefer model was then fitted with this additional information.

The two assessments provided results that were similar in nature. The effort at MSY (f_{MSY}) was almost identical. In fact, the difference in effort as a percentage of f_{MSY} was within 0.1% of each other. The assessments suggest that the effort would remain the same if you fish for local consumption or not.

Either assessment could be utilized. However, if using the assessment that incorporates local consumption, you need to subtract local consumption from the MSY before the quota allocation. Otherwise, the maximum sustainable yield will be exceeded. The present catch and effort appear sustainable.

2.8.4.5 Management

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

1. Determine the catch in relation to the produced MSY, while using the current fishing effort in relation to the effort producing MSY.
2. Do not exceed current effort levels, because the current effort suggests that it is operating within 88.1% of effort at MSY
3. Examine possibilities of hiring an economist to provide understanding of the economic pros and cons for the conch fishery
4. 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)

2.9 References

Anonymous. (1999). Report on the Queen Conch Stock Assessment and Management Workshop. Council and CARICOM Fisheries Resources Assesment and Management Programme. Belize City, Belize. 1-105 p.

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3. The Queen Conch *(Strombus gigas)* Fishery of Jamaica

Rapporteur: June Masters

3.1 Management Objectives

(i) To monitor and control the conch capture fishery to maintain optimum sustainable yields.
(ii) To promote the rehabilitation of overexploited stocks.
(iii) To obtain an optimum foreign exchange earnings from the export of conch
(iv) To obtain an optimum yield for local consumption by residents and tourists.

3.2 Status of Stocks

The 2002 visual survey assessed two zones, the 10 – 20 m zone, and the 20 – 30 m zone. Thus stock status determination was limited to these two zones. Results are available from three visual surveys as follows.

Year	Less than 10 m zone	10 – 20 m zone	20 – 30 m zone
1994	Surveyed	Surveyed	Surveyed
1997	Surveyed	Surveyed	
2002		Surveyed	Surveyed

10 – 20 m zone: Total abundance (57.9 million conch) in 2002 has decreased by 56% when compared to the 1997 survey (103.5 million conch). The mean exploitable stock density (adults) was 138 conch/ha. This is a 187 % increase over the 48 conch/ha found in 1997 (see Table 1).

It would appear that the abundant recruits in 1997 became adults in 2002, and were replaced by a much smaller recruitment (see Figure 1).

20 – 30 m zone: Total abundance (129.5 million conch) has increased by 26% when compared to the 1994 (102.4 million conch). The mean exploitable stock for the 20 – 30 m zone was 245 conch/ha for 2002, which is 20.7% above the 1994 estimate, which was 203 conch/ha (see Table 1).

3.3 Management Advice

The increase in exploitable stock in the 10 – 20 m zone could be a function of decreased fishing effort from 2000 - 2001 and the entry of conch into the fishery (recruitment) for the period. As it is not clear what may have accounted for the increase in the exploitable stock perhaps it would be prudent to keep exploitation levels stable in the fishery.

3.4 Statistics and Research Recommendations

3.4.1 Data Quality

Catch and effort data

Catch and effort and biological data collection should continue, and should sample the whole fishery (artisanal, mainland and all of the fishery on the Pedro Bank).

3.4.2 Research

- Estimates of unreported catch from Pedro Bank (requires two surveys to be conducted).
- There is a visual survey scheduled for November 2006. If a second survey could be done in a year's time (November 2007), this would allow for a current estimation of survival, fishing mortality, catchability coefficient and unreported catch (see Section 3.8).

3.5 Stock Assessment Summary

(a) Estimates of population density (number/ha) and abundance (total population).

(b) Population structure (size/age)

Table 1 shows estimates of population density and population structure for visual surveys done in 1994, 1997 and 2002.

Table 1. Estimates of mean density per hectare per age/class and total abundance, by management zone

MANAGEMENT ZONE	Year	Sites	Small juvenile	Medium juvenile	Large juvenile	Sub adult	Normal adult	Stoned adult	Total density	Total abundance	Juveniles/ha	Exploitable stock/ha
Artisanal (ART)	**1997**	5	48	92	33	48	65	28	316	11,673,500	222	93
	1994	7	0	8	0	7	20	53	89	3,293,000	15	73
10-20 m												
	2002	36	79	50	22	6	38	77	287	57,887,900	157	115
	1997	17	285	141	11	29	32	16	513	103,481,921	466	48
	1994	40	17	20	2	13	64	88	204	41,146,800	52	152
20-30 m												
	2002							245	350	129,500,000	105	245
	1997	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	1994	11	12	44	1	16	29	174	277	102,490,000	73	203

NB Abundance was calculated by multiplying the total density by the area of the stratum (37,000 ha, <10 m zone; 201,700 ha, 10 – 20 m zone; 37,000 ha, 20 – 30 m zone)

Figure 1. shows the abundant recruits found in 1997. It is possible that these recruits became adults in 2002, and were replaced by a much smaller recruitment.

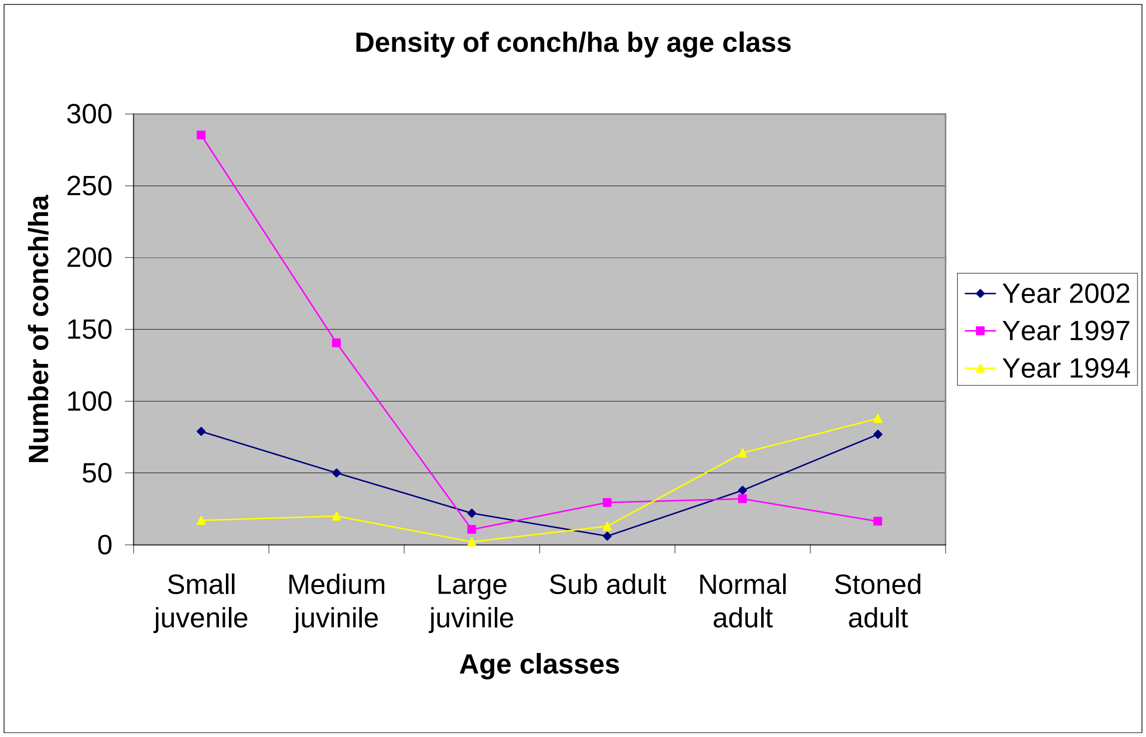

Figure 1. Density of conch/ha by age class observed for the 1994, 1997 and 2002 survey in the 10 – 20 m zone of Pedro Bank.

(c) Determine from the three visual surveys done the amount of unreported catch.

Formula to be used:

$$unreported\ catch = (recruited\ animals + recruits)\ in\ survey\ 1$$
$$-\,recruited\ animals\ in\ survey\ 2 - reported\ catch.$$

We were unable to estimate poaching as we were missing vital information

3.6 Special Comments
None.

3.7 Policy Summary
To manage the capture fisheries resources of Jamaica, to harvest each resource as close as possible to its optimal sustainable yield, which means reversal of over-fishing in overexploited fisheries and increasing fishing effort in under-exploited fisheries, and in the process to recover resource rents to finance the fishery management process.

3.8 Scientific Assessments

3.8.1 Background and description of the fishery

Background

In 1991 The Jamaica Fisheries Division conducted a Preliminary study of the queen stocks on the Pedro Bank (the major conch fishing ground). The study focused on the population found at the range of depth where commercial fishers were diving. The results provided a rough first estimate of the biomass and the maximum sustainable yield (MSY) of queen conch available to the fishery on the bank. The results suggested that the bank's conch stocks were being overexploited and if the levels of harvesting continued, the fisheries would collapse within three years (Mahon, Kong and Aiken 1992).

The second survey of November 1997 found mean densities of conch to be: 0-10 m, 316 conch/ha and 10-20 m, 513 conch/ha. The observations of mean densities although on the same order of magnitude as the previous survey and probably higher, showed that densities of adult normal and stoned conch had decreased more than 50% in the 10-20 m depth zone where the majority of the industrial fishery takes place (Tewfik and Appeldoorn, 1998). There was no information regarding the 20-30 m depth zone as it was not covered during the survey. The impact that conch from this latter zone may have on the fishery was therefore not fully appreciated. Subsequently, MSY was estimated at 1366 MT. (Smikle & Appledoorn 2002). Results are available from three visual surveys as follows in Table 1.

Table 1: Total catch, CPUE, recruitment, population and F for queen conch at Pedro Bank Jamaica

Year	References	Total catch	CPUE	Recruitment	Population	F
1994 / 1995	Appeldoorn, 1995	16280000	277		108569510	0.18
1995 / 1996	Tewfik and Appeldoorn, 1998	15466000	193	9643840	80139158	.24
1996 / 1997	Smikle and Appeldoorn, 2003	14652000	161	20672910	65149523	.29
1997 / 1998		13838000	176	7831605	44108175	.43

Table 2: Annual reported exports (=catch) and quotas in the Jamaican conch fishery since the time of the last survey (1997).

Year	**Export (mt) = catch**	**Quota (mt)**
1998	1904	1700
1999	1005	1366
2000	10	1216
2001	745	946
Average	916	1307

Source: 2002 Estimates of abundance and potential yield for the Pedro Bank Queen Conch Population (Smikle & Appledoorn 2002)

The 2002 Estimates of abundance and potential yield for the Pedro Bank Queen Conch Population showed the mean exploitable stock density was 138 conch/ha with 95% confidence limits of 90 - 180 conch/ha. According to Smikle & Appledoorn (2002), since the last survey (1997) the average harvest rate of approximately 900 mt was sufficient to result in an apparent increase in stock size. They further recommended an annual harvest level of 800-900 mt.

Description of the fishery

The Queen Conch (*Strombus gigas*) fishery is the most valuable foreign exchange fishery in Jamaica. This resource is exploited on the island shelf and offshore banks. The predominant fishery occurs on the Pedro Bank. At present it is estimated that up to 95% of the conch landed in Jamaica originates from the Pedro Bank. However, small amounts are also fished from the Formigas Bank and Morant Banks. The amount of conch landed from the island shelf is so far not quantified but may be significant.

The conch industry is divided into an artisanal and industrial fishery.

Artisanal Fishery

The artisanal fishery may be described as:

(1) **Mainland artisanal** – these are fishers based on the mainland or island shelf of Jamaica. They were originally free divers who now use SCUBA gear for diving. These fishers are usually part time conch fishers. They sell Conch mainly to processors and the local market.

(2) **Offshore artisanal** – these fishers are based on the Pedro Bank. They use SCUBA or hookah gear for diving. These fishermen sell their catch to packer (small carrier) boats, which ply the route from mainland Jamaica to the Pedro Cays. The packer boats operators sell the conch mean mainly to processing plants.

Industrial Fishery

This fishery is dominated by large producers who harvest conch for export. These fishers are based on the mainland. They fish the Pedro bank using motor fishing vessels of 20-35m. Most of the vessels are leased from countries such as Dominican Republic and Honduras. The vessel crew contingent including fishers averages 30 persons of which most of the divers are foreigners

3.8.2 Overall Assessment Objectives

(1) To compare the findings of the 2002 visual survey to the findings of the similar surveys of 1994 and 1997.
(2) To determine scientifically the magnitude of poaching on the Pedro Banks of Jamaica.

3.8.3 Data used

Name	**Description**
Estimates of conch density from visual surveys of the Pedro Bank.	Mean number of conch encountered over all transects completed at a site and extrapolated to one hectare (ha = 10,000 m^2)

3.8.4 Assessment 1

3.8.4.1 Objective

To compare the findings of the 2002 visual survey to the findings of the similar surveys of 1994 and 1997.

3.8.4.2 Method and Data

Visual surveys were carried out on the Pedro Bank in 1994, 1997 and 2002

Pedro Bank was stratified into three zones defined primarily by management considerations. Results are available from three visual surveys (Table 3).

Table 3

Years references and zones surveyed by visual survey on the Pedro Bank Jamaica

Year	References	Less than 10 m zone	10 – 20 m zone	20 – 30 m zone
1994	Appeldoorn, 1995	Surveyed	Surveyed	Surveyed
1997	Tewfik and Appeldoorn, 1998	Surveyed	Surveyed	
2002	Smikle and Appeldoorn, 2003		Surveyed	Surveyed

Two teams of divers swam 3 x 100 m transects (sampled 300 m^2) searching for all conch on or buried in the sediment within 1.5 m. Estimates of conch density were based on mean number of conch encountered over all transects completed at a site and extrapolated to one hectare (ha = 10,000 m^2) for all size/age categories as well as total conch and the exploited stock. The later is defined as the sum of normal plus stoned adult conch. Total abundances of conch were calculated y multiplying density (conch/ha) in a given zone or stratum y the total area of that zone. For the 10 – 20 m stratum, the area was 201,700 ha, for the 20 – 30m stratum the area was 370, 000 ha. Computations of the densities were done within a spreadsheet program (excel). Confidence limits (95 %) for all estimates were calculated by the bootstrap method using custom made software (WinGLFA ver. 2.0) (Appeldoorn and Tewfik, 1998).

3.8.4.3 Results

Table 4.

Estimates of mean density per hectare per age/class and total abundance of queen conch **(***Strombus gigas)* found on Pedro Bank Jamaica**, by management zone for** the years 1994, 1997 and 2002**.**

MANAGEMENT ZONE	**Year**	**Sites**	**Small juvenile**	**Medium juvenile**	**Large juvenile**	**Sub adult**	**Normal adult**	**Stoned adult**	**Total density**	**Total abundance**	**Juveniles/ha**	**Exploitable stock/ha**
Artisanal (ART)	**1997**	5	48	92	33	48	65	28	316	11,673,500	222	93
	1994	7	0	8	0	7	20	53	89	3,293,000	15	73
10-20 m												
	2002	36	79	50	22	6	38	77	287	57,887,900	157	115
	1997	17	285	141	11	29	32	16	513	103,481,921	466	48
	1994	40	17	20	2	13	64	88	204	41,146,800	52	152
20-30 m												

	2002							245	350	129,500,000	105	245
	1997	N/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a			
	1994	11	12	44	1	16	29	174	277	102,490,000	73	203

NB Abundance was calculated by multiplying the total density by the area of the stratum (37,000 ha, <10 m zone; 201,700 ha, 10 – 20 m zone; 37,000 ha, 20 – 30 m zone)

Investigation of the 20 – 30m zone was not completed due to mechanical difficulties. Data was collected from seven sites, and preliminary results indicate that station densities in the 20 – 30 m stratum ranged from 83 to 648 conch/ha for all age classes with an average total density of 350 conch/ha (using bootstrap calculated 95% confidence limits).

Table 5
Preliminary estimates of mean density per hectare per age/class and total abundance of queen conch (*Strombus gigas)* found on Pedro Bank Jamaica, in management zone 20 -30 m for the years 2002 (without using bootstrap calculated 95% confidence limits).

Number of conch sampled by Age / Size Category

Sm Juv	**Me Juv**	**Lr Juv**	**Sub Adult**	**Adult**	**Stoned**	**Total**
52.37571	128.5586	180.9343	38.09143	104.7514	47.61429	552.3257

3.8.4.4 Discussions
The overall density and abundance of conch on Pedro bank in the most heavily exploited zone 10 - 20 m zone has declined by 44% since 1997 (287 conch per hectare 2002; 513 conch per hectare 1997) but are of greater magnitude than that reported for the 1994 survey (204 conch per hectare). As with the 1997 survey, the 2002 survey also shows critical changes in the distribution of density amongst the six size/age categories in the 10-20 m zone. The small juvenile, medium juvenile have decreased in abundance by 261%; and 182% respectively, and large juveniles, sub adults, normal adults and stoned adults have all increased by 50%; 263%; 19%; 381% respectively. The apparent decline in juveniles is not cause for alarm as Tewfix and Appeldoorn (1997) had speculated that the reason(s) for the marked increase in the small and medium juveniles (which had increased dramatically over the 1994 figure) in both the Artisinal and 10 – 20 m zones could have been due to the availability of habitat and food resources for incoming larvae as a result of normal and stoned adults being removed by harvest or as a result of an unusually high settlement of larvae in a natural cycle that may only occur every so often.

Preliminary indications for size/age categories in the 20-30m zone for 2002 when compared to the 1994 findings is that the age structure of this zone could have also changed.

3.8.5 Assessment 2

3.8.5.1 Objective
Determine from the three visual surveys done the amount of unreported catch.

3.8.5.2 Method and Data
This was attempted with the 1997 and 2002 visual survey data

Formula to be used:

$$unreported\ catch = (recruited\ animals + recruits)\ in\ survey\ 1$$
$$- recruited\ animals\ in\ survey\ 2 - reported\ catch.$$

It is assumed that natural mortality between the two surveys is zero (although natural mortality could be accommodated if an estimate is available. Given the results of the two surveys, the survival rate can be estimated as;

$$\textit{Estimated survival} = \frac{\textit{recruited animals in year 2}}{\textit{recruited animals + recruits in year 1}}$$

the exploitation rate represented by the reported landings is estimated as

$$\textit{exploitation rate (reported)} = \frac{\textit{reported catch}}{\textit{recruited animas in year 1}}$$

the unreported catch is;

unreported catch = (recruited animals + recruits) in survey 1
- recruited animals in survey 2 – reported catch.

The exploitation rate due to unreported catch is estimated as unreported catch/abundance of recruited animals in survey 1. The total exploitation rate is estimated as (reported + unreported catch) / abundance of recruited animals in survey 1 . Finally, the instantaneous fishing mortality rate, F yr^{-1}, and the catchability coefficient, q, can be estimated as;

$$F = -\log_e(1-u)$$

and

$$q = F/f$$

where f is the total effort between the two surveys.

3.8.5.3 Results

This was attempted but the data collected from both surveys was not sufficient to allow for the calculations

3.9 References

Appeldoorn, R. S. (1995). Stock abundance and potential yield of the queen conch of Pedro Bank. Univ. Puerto Rico / Fisheries Div. Jamaica, 30 p.

Mahon, R., Kong, G. A. and Aiken K. 1992. A preliminary assessment of the conch fishery on the shelf and banks off the south coast of Jamaica. *CARICOM Fishery Research Document* No. **8**

Smikle, S. G. and Appeldoorn, R. S. (2003). 2002 Estimates of abundance and potential yield for the Pedro Bank queen conch population. Fisheries Div. Jamaica 20p.

Tewfik, A. and Appeldoorn, R. S. (1998). 1997 queen conch (*Strombus gigas*) abundance survey and potential yield estimates for Pedro Bank. Fisheries Div. Jamaica 39 p.

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

Rapporteur: Lester Gittens

4.1 Management Objectives

The primary management objective for the spiny lobster fishery is to ensure that spiny lobsters are harvested for maximum economic benefit and in a sustainable manner.

4.2 Status of Stocks

The current status of the lobster fishery is not known. Time constraints did not allow for an in depth analysis of the lobster fishery due to a higher priority being placed on conch.

4.3 Management Advice

Given the great economic importance of the lobster fishery, every effort should be made to improve assessments and take advantage of future assessment opportunities such as those offered by the FAO and CRFM. In addition, efforts need to be made to build the capacity to assess the fishery as needed. This is in order to facilitate the best management possible for the fishery.

4.4 Statistics and Research Recommendations

4.4.1. Data Quality

Data collected by the Bahamas appears to be of sufficient quality to assess the biological status of the fishery. It is unknown if the economic data collected would enable the success of the earlier stated management goal for the fishery to be measured.

4.4.2. Research

For lobster, it is recommended that export data be used to recreate length-frequencies in order to calculate growth rates and mortality rates. This could also be used in conjunction with catch per unit effort data to determine biomass trends. It is also recommended that economic indicators be incorporated into analyses of the fishery in order to measure the success of implementing the goal of the fishery.

Management goals may also need to be revised to reflect a more specific aspect of maximum economic benefit, e.g., maximum employment, maximize profits per fisher or maximize profits for the country.

4.5 Stock Assessment Summary

4.5.1. Spiny Lobster

Records of total weight of commercial export grades were used in conjunction with samples of tail length from each commercial grade in order to recreate tail length frequency (Figure 1) of the catches that the exports originated from. Multiple modes were evident, thus the recreated data appears to be suitable for length-frequency analyses.

4.6 Special Comments

None.

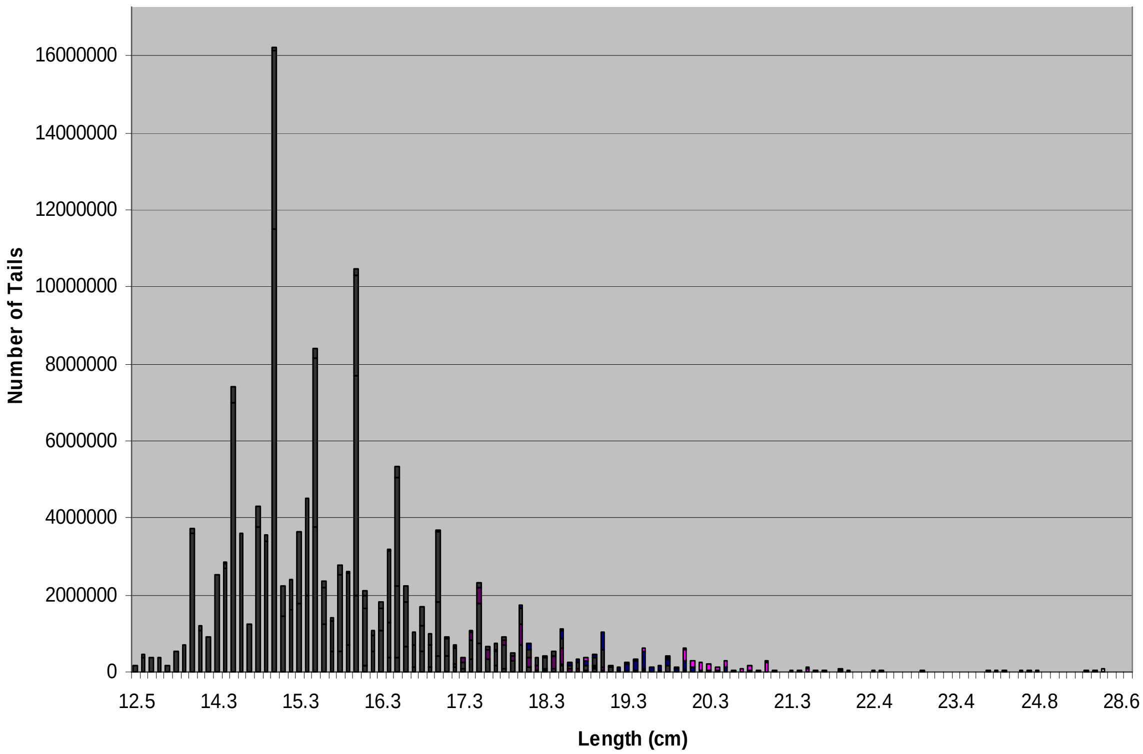

Figure 1. Recreated Tail Length-Frequency Distribution of *Panulirus argus*

4.7 Policy Summary

The policy for the lobster fishery calls for maximum economic benefit to be achieved within the parameters of sustainable utilization of the resource. The limited analyses conducted on spiny lobster at the present workshop did not allow for the policy to be addressed.

4.8 Assessment

An assessment was not completed for the spiny lobster fishery due to time constraints related to greater emphasis being placed on completing a more comprehensive assessment of the queen conch fishery. Nevertheless, the work done for the spiny lobster fishery at the present workshop facilitates future assessments of the lobster fishery.

Size-frequency analysis is often needed to complete spiny lobster stock assessments due to the difficulties associated with determining the age of lobsters. During the present workshop the length-frequency distribution of lobster tails from the commercial fishery was recreated from samples obtained from commercial export grade categories that were based on weight. The commercial export grades that were sampled consisted of broad weight categories. Sampling of tail lengths in each of the commercial weight categories has allowed the weight categories to be converted to a more precise size frequency representation in the form of tail length-frequency.

Most spiny lobster exported in the Bahamas is exported. The weight- frequency of all commercially exported lobsters is reported to The Department of Marine Resources. The tail length-frequency recreation should therefore be representative of all lobsters landed in the commercial fishery. Visual inspection of Figure 1 shows that multiple modes are present. Analysis of the recreated length-frequency data should therefore facilitate the completion of a worthwhile stock assessment in the near future.

5.0 The queen conch (*Strombus gigas*) fishery of the Bahamas

5.1 Management Objectives

The management objective for the conch fishery is to ensure that conch is harvested in a sustainable manner while attempting to meet local demand firstly and foreign demand secondly.

5.2 Status of Stocks

Based on landings and catch per unit effort trends, the conch fishery appears to be stable as a whole. Of particular note in this fishery was that there were signs of little fluctuation in population size in some areas while other areas had evidence of population growth. There were also signs of localized depletions.

5.3 Management Advice

Although there are indications of stability on most fishing grounds, given the uncertainty involved with stock assessments in addition to the relative complexity of this fishery, that spans multiple fishing grounds that each occupy vast areas, additional precautionary management tools are recommended in order to further protect the fishery. Given the insights into the status of different fishing grounds that were made available through the work completed at the present workshop, management tools focused at possibly problematic fishing grounds are also more of a management option.

5.4 Statistics and Research Recommendations

5.4.1. Data Quality

The data provided allowed for the general biological status of the fishery and major fishing grounds to be ascertained. This can thus help to focus the government's limited resources on the areas that most need them and thus help to achieve the goal of managing the fishery in a sustainable manner.

5.4.2. Research

Greater sampling coverage in terms of area specific and total landings estimates and area specific and total catch per unit effort would enhance biological assessments of the fishery and help to determine suitable yields for the fishery. Obtaining growth statistics such as shell length and lip thickness may also enhance assessments of the fishery.

5.5 Stock Assessment Summary

Analyses of catch per unit effort and landings trends indicated overall stability with no strong trend in both indicators of fishery performance when they are considered as a whole over the last 17 years and 27 years respectively (Figures 1 and 2). On an individual basis there were signs of constant abundance (Figures 3 and 4), increasing abundance (Figure 5), decreasing abundance (Figure 6) and low abundance (Figure 7).

In general, the catch per unit effort trends and landings trend concur with anecdotal observations concerning the fishery, i.e., if one area becomes depleted there are many other areas to turn to.

Application of a Schaefer Dynamic Model was also attempted and resulted in a good fit to the observed data. However, the parameter estimates were not stable thus making conclusions from this aspect of the analysis unreliable at the moment.

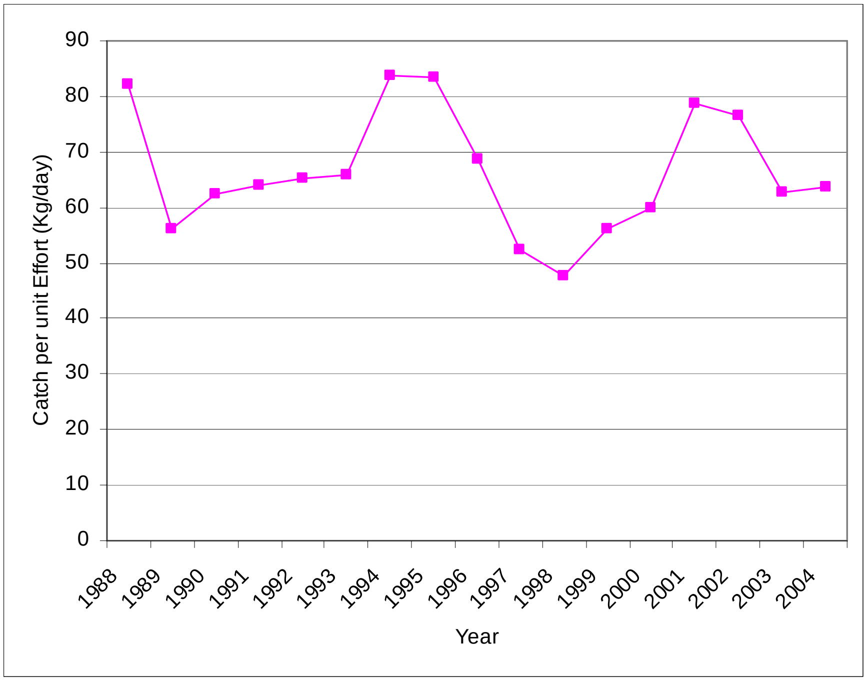

Figure 1: Catch per unit Effort in The Bahamas (1988-2004)

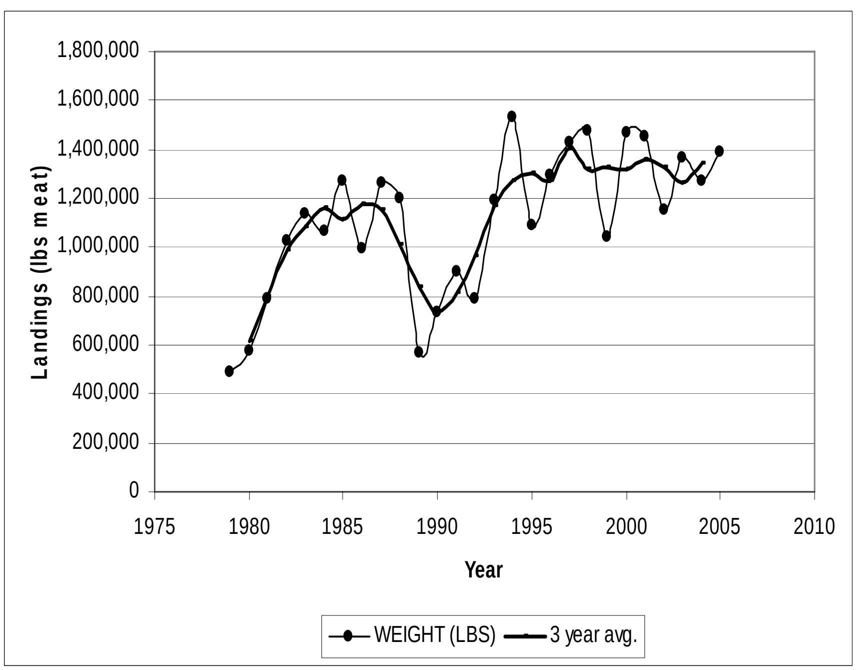

Figure 2: Landings in The Bahamas (1988-2004)

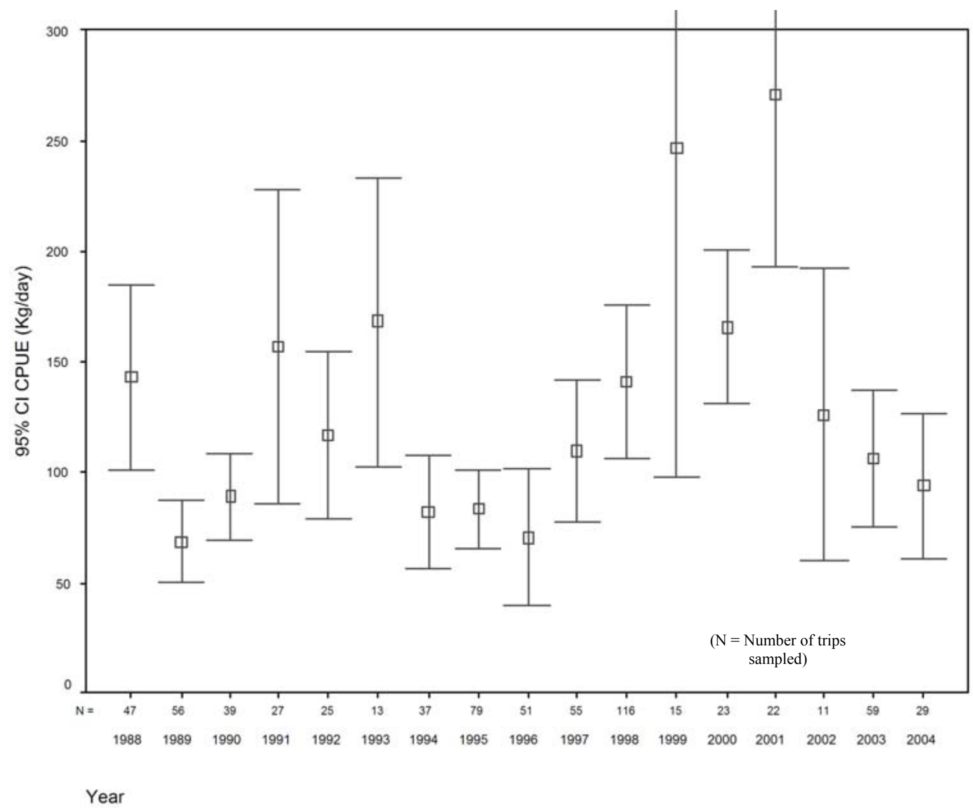

Figure 3: Catch per Unit Effort at Abaco (1988-2004)

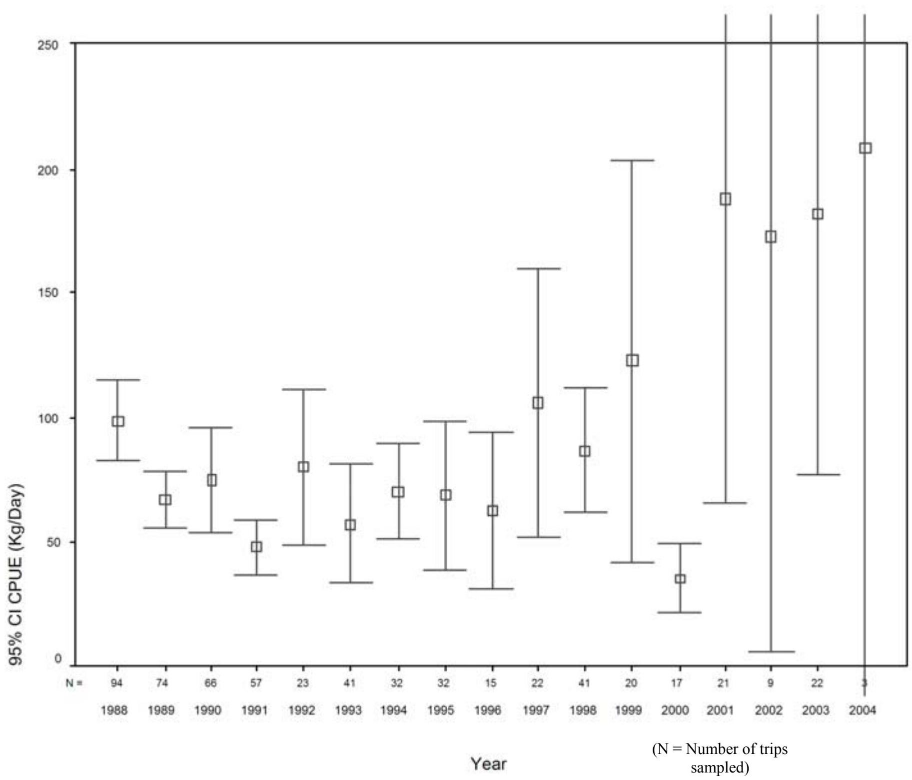

Figure 4: Catch per unit Effort at Andros South (1988-2004)

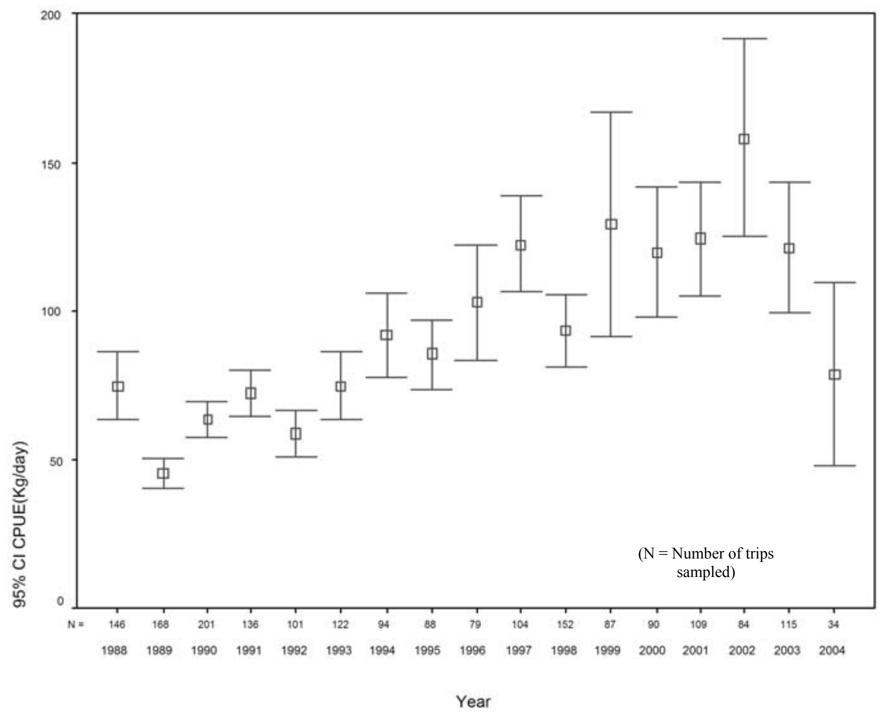

Figure 5: Catch per unit Effort at the Berry Islands (1988-2004)

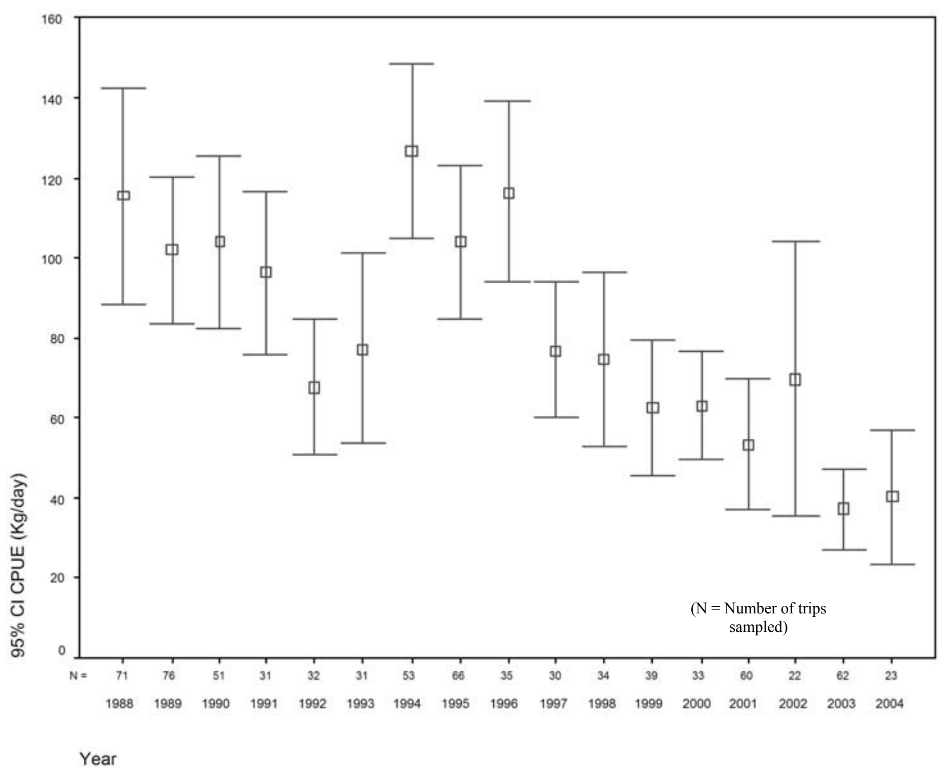

Figure 6: Catch per unit Effort at Fishing Grounds at Exuma (1988-2004)

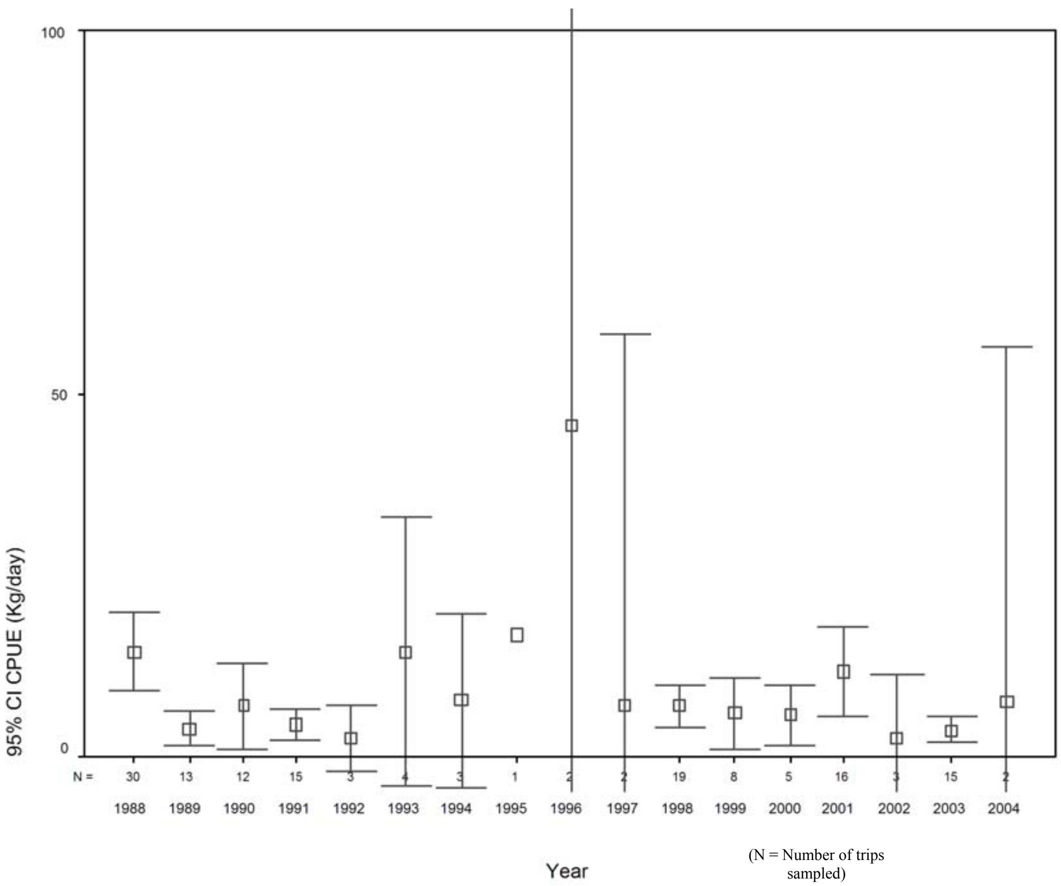

Figure7: Catch per unit Effort at New Providence (1988-2004)

5.6 Special Comments

The last thorough biological assessment of conch fisheries in the Bahamas was completed in 1999 and showed that the fishery was stable at that time with abundant biomass (Ehrhardt and Deleveaux 1999). Analyses conducted at the present workshop give evidence that the conch fishery remains stable and that harvests in the near future will not be detrimental to the fishery.

5.7 Policy Summary

The policy for the queen conch fishery calls for sustainable use of the resource with emphasis on supplying the Bahamian market firstly and the foreign market secondly. The analyses provided during the present workshop suggest that the fishery has been stable overall. Given that commercial exports have been taking place since 1993, the fishery's stability suggests that it can sustain exports in addition to meeting local demand.

5.8 Scientific Assessments

5.8.1 Background or Description of the Fishery

The commercial fishing industry of The Bahamas is based primarily on the Little Bahama Bank and the Great Bahama Bank. Cay Sal Bank is also beginning to emerge as a major conch fishing ground.

Commercial fishing vessels range in size from 11 ft to 100 ft. A fisheries census conducted in 1995 showed that there were approximately 9,300 fulltime fishers and over 4,000 small boats and vessels. The dinghy is the main type of vessel used in the conch fishery. In many instances these small vessels (< 20 ft long) work in conjunction with a larger motorized "mothership" that acts as a base for operations.

Queen conch is exploited primarily near densely populated islands and at depths accessible by free diving and hookah gear. The Queen Conch is primarily collected by hand while diving (hookah and free diving) and is landed in the shell or as frozen meat in bags.

Due to the low monetary value of conch (approximately U.S. $3/lbs) compared to spiny lobster (approximately U.S. $15/lbs), fishing effort for conch is relatively low for the 8 months of the year that the spiny lobster fishery is open. Conch is targeted mainly during the seasonal closure of the spiny lobster fishery with over 2/3 of conch landings taking place during this 4 month period.

5.8.2 Overall Assessment Objectives

The overall objective was to conduct a biological assessment of the queen conch fishery that yields accurate information concerning the biological status of the fishery. Where possible the success of achieving the management objectives for the fishery stated in Section 1.1 is to be measured.

5.8.3 Data Used

Name	Description
Catch per unit effort (Kg/day fishing)	Calculated based on interviews and landings inspections from 1988-2004; fishing grounds specified
Total landings (Kg)	Sum of interview and processing plant records 1974 -2005; pertains to conch meat

5.8.4 Assessment

5.8.4.1 Objective

The specific objective of the analyses was to determine conch abundance trends for the Bahamas as a whole and for individual major fishing grounds with a view to determining the biological status of the fishery.

5.8.4.2 Method/Models/Data

The methodology used is outlined below:-

1. Records of catch and days fishing for individual fishing trips were used to estimate mean catch per unit effort per year for major fishing grounds as a whole and on an individual basis for the years 1988-2004.

2. Error bar charts with 95% confidence intervals of mean catch per unit effort vs. year were then plotted using SPSS for major fishing grounds and for the Bahamas as a whole. This was in order to assess fluctuations in abundance as well as accuracy of the calculated means.

3. Total fishing effort was unknown. Therefore, landings records pertaining to total landings for the Bahamas were then used to estimate total effort hereafter referred to as effective effort. The formula used is as follows:-

   Effective effort = Catch ÷ Catch per unit effort

4. Plots of catch vs. effective effort and catch per unit effort vs. effective effort were then followed to gain further insight into the status of the fishery and explore the use of a surplus production model for assessing the fishery.
5. A surplus production model in the form of a Schaefer Dynamic Model in the form of a spreadsheet written by consultant Paul Medley PhD was then applied using the calculated effective effort and total catch data for the Bahamas as a whole.

6. Input parameters from the Turks and Caicos Islands were then used to inform the Schaefer Dynamic Model while it was being applied to the data mentioned in 5 above.

7. Queen conch harvests per hectare were then estimated using the following formula:-

   Number of conch/ha = Total Number Harvested / Area Fished

   To obtain number of conch harvested the following formula was used:-

   Total number of conch harvested = Total Landings / Mean Meat Weight

8. The harvest per hectare was then put into perspective by making comparisons between calculations based on the total shallow water area within the Bahamas exclusive economic zone (15455300 ha), 50% of the total area and 10% of the total area.

5.8.4.3 Results

<u>5.8.4.3.1 Catch per unit Effort Analyses</u>

Catch per unit effort and landings of queen conch have fluctuated since 1988 and 1974 respectively, however, there is no strong overall trend in either measure of fishery performance over their respective time series when the Bahamas is considered as a whole (Figures 1 and 2, Section 1.5).

Total landings estimates specific to each fishing ground was unavailable however with regards to catch per unit effort trends there were signs of constant abundance at Abaco (Figure 3) and South Andros (Figure 4) with no obvious increase or decrease in catch per unit effort over the 17 year period of 1988-2004.There were also signs of an overall increase in abundance at the Berry Islands (Figure 5) although 2003 and 2004 had consecutive declines. Exuma showed a consistent gradual decline in abundance. Grand Bahama (Figure 8) and Eleuthera (Figure 9) were inconclusive with regards to overall trends due to a short time series and somewhat sporadic fluctuations in calculated catch per unit effort. With regards to determining trends from error bar charts less weight was placed on means that have very wide confidence intervals in addition to very small sample sizes.

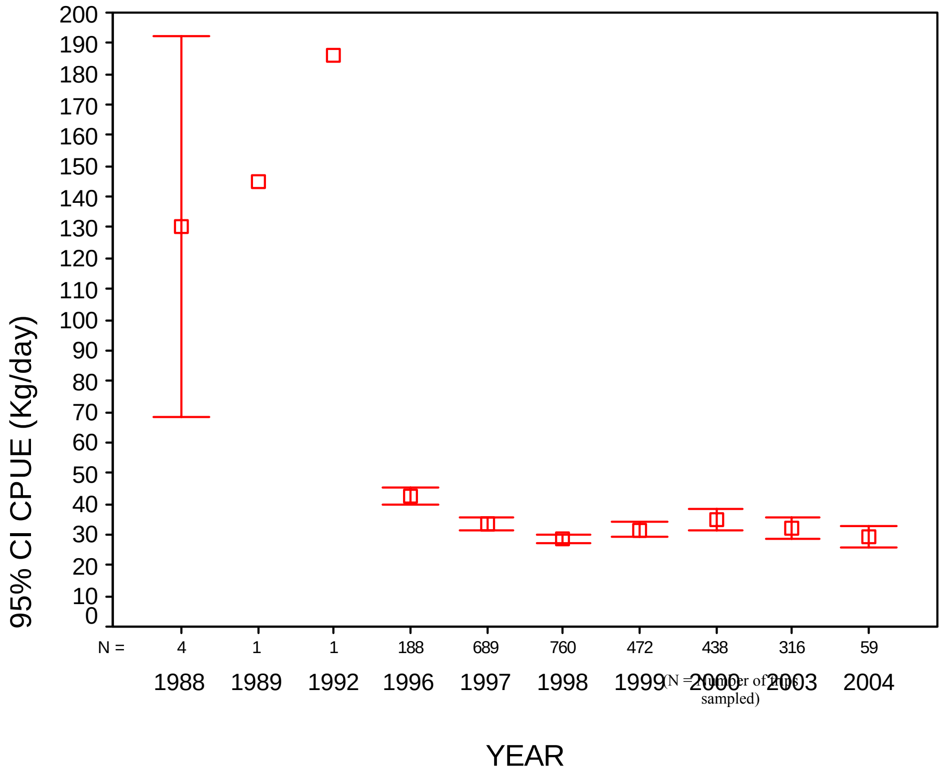

Figure 8: Catch per Unit Effort at Grand Bahama (1988-2004)

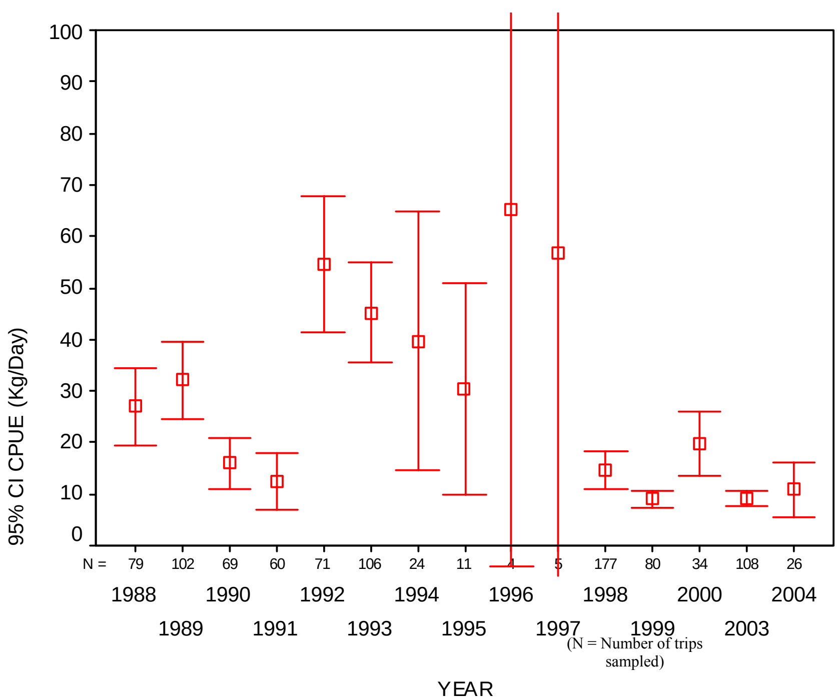

Figure 9: Catch per Unit Effort at Eleuthera (1988-2004)

There were also great differences in catch per unit effort between fishing grounds (Figure 10) when the period 1988-2004 is considered as a whole. Abaco had the best CPUE whereas New Providence had the poorest catch per unit effort. (NP = New Providence; Eleuth = Eleuthera; GB = Grand Bahama)

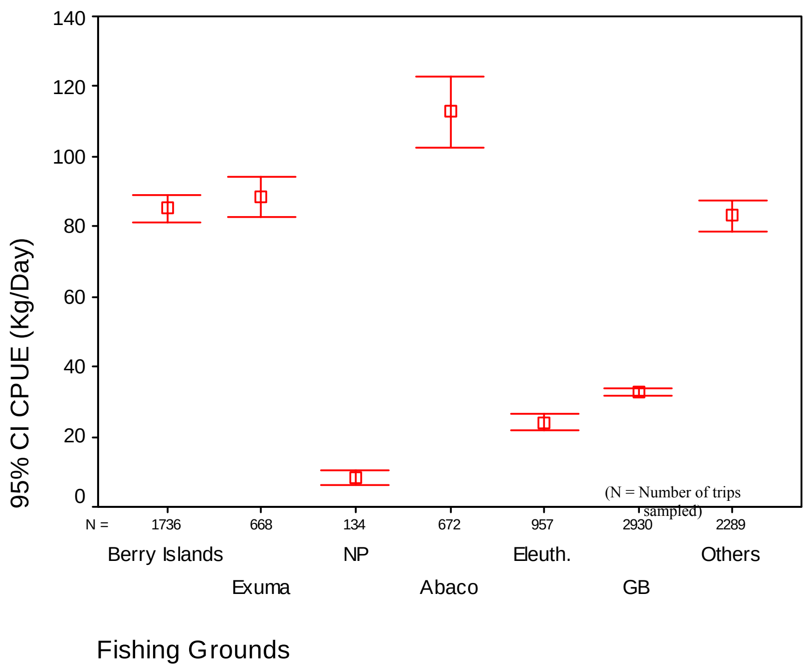

Figure 10: Catch per Unit Effort at Various fishing Grounds (1988-2004)

A plot of catch versus effective effort for the entire fishery showed great variation between 1988 and 2004 (Figure 11). There were periods of sharp increases in catch when effective effort is increased and periods of relatively modest increases in catch when effective effort is increased. Also at a given value of effective effort there was variation in the amount of catch over the time period.

Application of a Schaefer Dynamic Model **[B(t+1)=B(t) + r B(t) (1-B(t)/K) - Catch(t)]** yielded the following parameters and the fit seen in Figure 12:-

r = 0.94
K (carrying capacity) = 23,094,328
initial stock as a proportion of virgin = 0.105

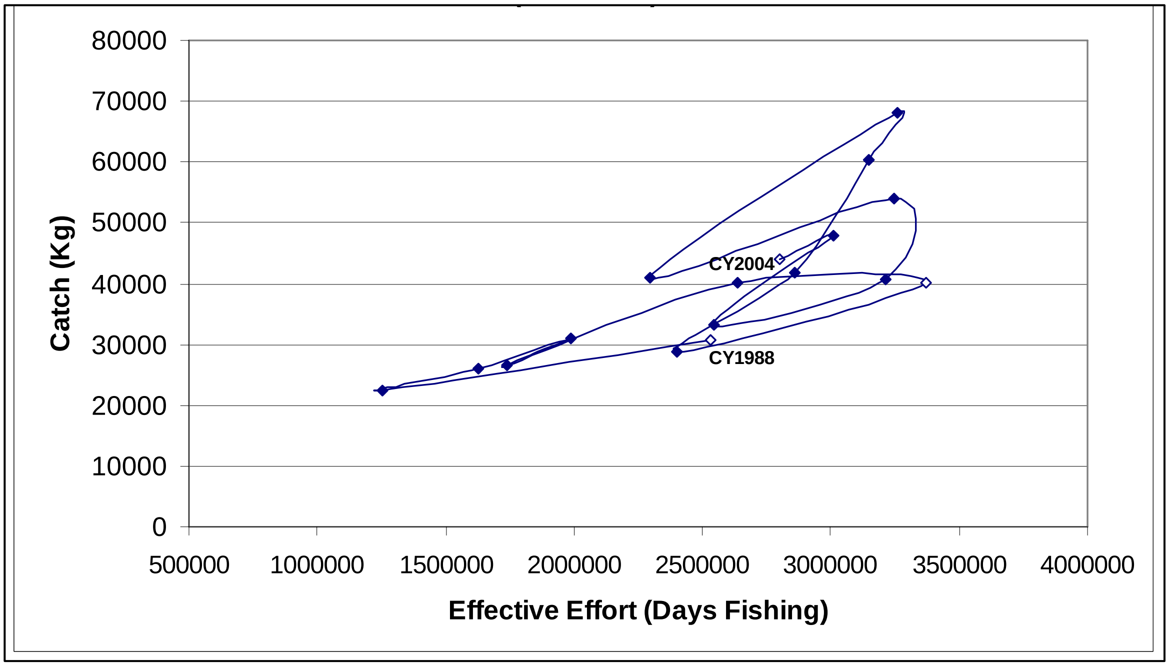

Figure 11: Catch vs Effective Effort for the Bahamas Queen Conch Fishery (1988-2004)

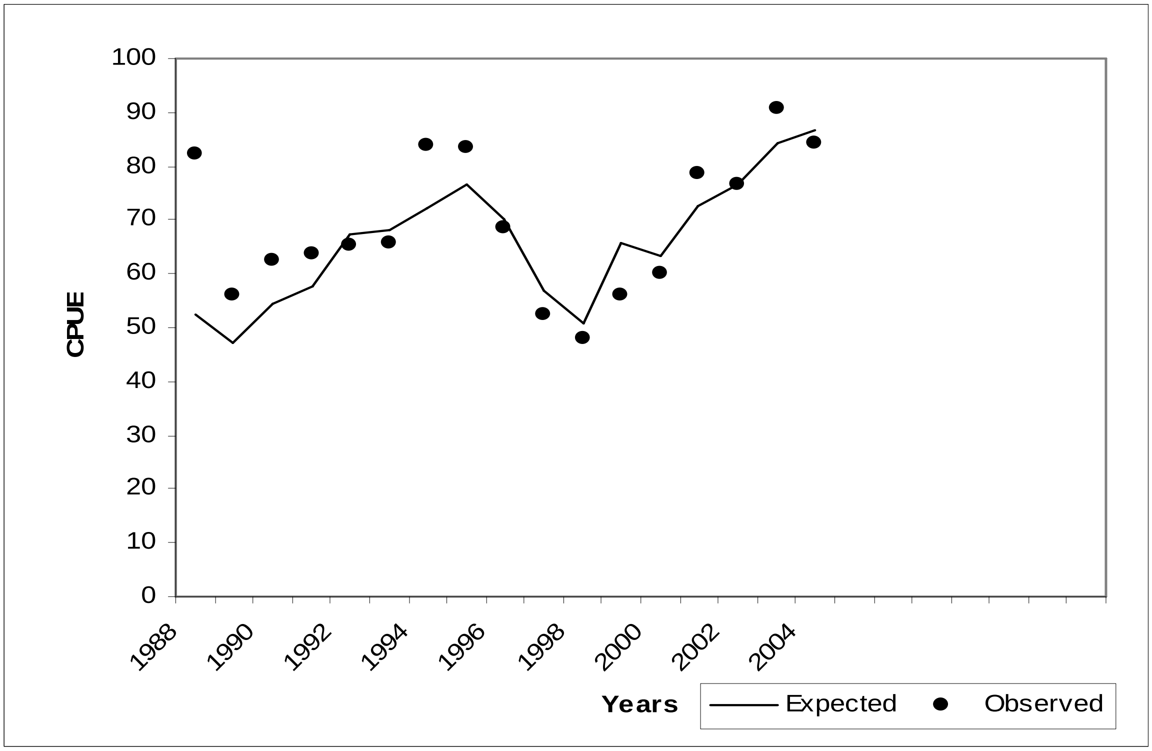

Figure 12: Observed and Predicted CPUE based on Schaefer Dynamic Model (Uninformed Model)

An attempt was made to inform the model using a more realistic r value of from the Turks and Caicos Islands queen conch fishery and resulted in the fit seen in Figure 13. The resulting predicted catch per unit effort trends were obviously nonsense (Figure 13).

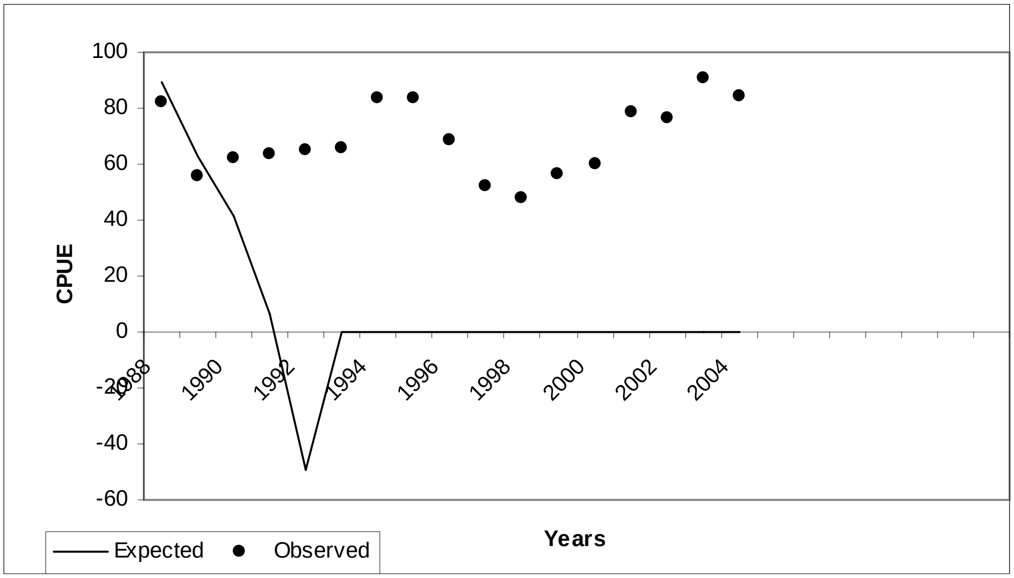

Figure 13: Observed and Predicted CPUE based on Schaefer Dynamic Model (Informed Model)

5.8.4.3.2 Harvests per Hectare Analyses

Meat weight samples were available for a number of areas in the Bahamas and various times between 1996 and 2004 (Table 1).

Table 1: Mean Meat Weight of Queen Conch Harvested in The Bahamas

SOURCE	MEAN MEAT WEIGHT (g)	NUMBER OF SAMPLES	STANDARD DEVIATION
Abaco FG	95.273	44	23.766
Abaco LS	94.036	13664	62.801
Berry Islands FG	63.439	49	12.269
Exuma FG	84.364	11	15.857
Grand Bahama LS	137.016	161	15.430
New Providence LS	120.839	84	35.357
Total	**94.580**	14013	62.345

FG – fishing Grounds; LS – Landing Site

Estimates of harvest per hectare were calculated based on the overall mean meat weight estimate of 94.6 g. Based on this, the number of conch harvested per hectare remained below 2.5 individuals per year (Figure 14) when the entire shallow water area (less than 20m depth) of the Bahamas is considered to be conch habitat. If only 50% of the shallow water is considered conch habitat then harvests per hectare have been at or below 4.6 individuals per year (Figure 14). If as little as 10% of the bank had conch then harvests per hectare were below 25 individuals per year.

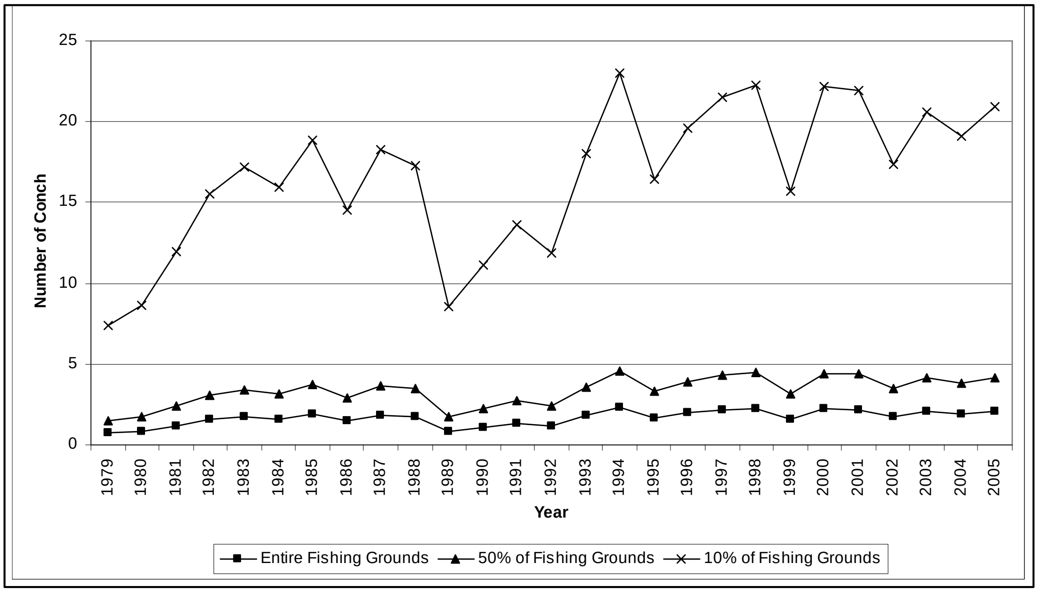

Figure 14: Estimates of Number of Conchs Harvested per Hectare

5.8.4.4 Discussion

The most reliable results that apply to the fishery as a whole (i.e. total landings and overall catch per unit effort) give an indication that the queen conch fishery is stable as a whole as both do not show an overall declining trend over their respective time periods. While this information is valuable for making informed management decisions, ideally information pertaining to appropriate yield and fishing effort should be incorporated into making management decisions.

The variations in catch versus effective effort (Figure 11) indicated a good possibility that a surplus production model could be fitted to the data currently available. Hence an attempt was made to fit a Schaefer Dynamic model to the data. The Schaefer Dynamic model appeared to have a good fit to the data initially, however, the resulting parameter estimates indicated that conclusions to be drawn from it were unreliable, for example, r, as estimated for the Turks and Caicos Islands during the present workshop was 0.4 whereas for the Bahamas it was estimated to be approximately 0.9. In addition, the model suggests that at the beginning of the time series analyzed (1988), the overall stock was at a mere 10% of virgin biomass. A biomass of 10% seems quite unlikely given the stable landings trend and catch per unit effort trends in the 16 year period analyzed since that time. Stoned conchs (conch that attained an age of maturity long ago) are also still commonly landed in the fishery which indicates that adults, i.e. spawning stock, are abundant. The results of the Schaefer model were not stable; e.g. it was difficult to find the global minimum of the sum of squares suggesting the parameters were not well determined.

Although the parameter estimates based on the Schaefer Dynamic Model appear to be unreliable, further exploration of its use is warranted given that the model showed potential for being fit to the data and because of the need to further improve the management decision-making process.

The further attempt to do this by informing it using r from the Turks and Caicos Islands did not yield results that can inform a management decision; however, other avenues of improving the fit exist and include conducting analyses for individual fishing grounds. This would require estimates of total landings from each fishing ground and ideally estimates of total effort instead of effective effort. A longer time series would also be better.

A complicating factor in applying the model to the fishery as a whole is that landings trends and thus effective effort would be affected by fishers depleting one area then moving to the next; thus depletions of individual major areas may not be reflected. However, analysis of the fishery as a whole is still valuable because of the particular circumstances of the Bahamas, i.e. there are many vast conch fishing grounds some of which are unexploited. In an analysis of individual fishing grounds only, this information may not be reflected and may give the impressions that the overall fishery is in a worse state than it actually is.

Also, in the event that more complex analyses are not possible for the fishery as a whole, a declining trend in overall CPUE should be a reliable indicator of major trouble for the entire fishery. If a major declining trend develops in CPUE for the whole fishery this would likely mean that abundance on most fishing grounds is declining and that no new areas are available.

When CPUE is analyzed for individual fishing grounds, the results show that some of the current major fishing grounds have varying levels of abundance with signs of stability and instability depending on the fishing ground, with high CPUE, low CPUE, increasing CPUE and decreasing CPUE being seen. In the instance where CPUE is low throughout the time series, namely, New Providence, a conclusion cannot be drawn about the state of the fishery solely from the analyses presented here. This is because it has not been demonstrated that the area ever had conch in greater abundance in the past. Here anecdotal evidence is valuable. Most older persons will state that conch was much more abundant around New Providence in the past. Based on this, the observed CPUE for New Providence fishing grounds indicates that it is likely in an overfished state. This is not surprising given that the largest population centre is on New Providence and queen conch is a traditional staple in the Bahamian diet.

The estimates of harvests per hectare help to put into perspective the vastness of fishing grounds in the Bahamas and how difficult it would be to overfish the entire Bahamas. Even if only 50% (7,727,650 ha) of the shallow water area of the Bahamas was conch habitat, then the harvests per hectare over the 2 ¾ decades depicted in Figure 14 would have amounted to less than 5 conchs per hectare per year. If 56 conchs / ha is considered the minimum density necessary for reproductive success, then the removal of less than 5 conchs/ ha is highly unlikely to cause reproductive failure or collapse of the fishery even if the fishery started at the minimum of 56 conch/ ha at the beginning of the 1978-2005 time period. This is especially so because conch is believed to have a very low natural mortality and recruitment should have been constantly taking place. A complicating factor in the calculations presented here is that a portion of conch landings is unreported. This proportion is unknown but it is believed that most landings are recorded. Underestimated landings would have the effect of underestimating the number of conch harvested per hectare.

The estimate based on conch habitats being only 10% (1545530 ha) of the total shallow water area represents a scenario that is very unlikely for the Bahamas. This is because the harvests per hectare averaged 17 conchs per year over the 27 year period. For the fishery to have survived for so long would mean that conch density was unrealistically high initially. For example, if the density was initially as high as 200 conchs / ha and an average of 17 conchs/ha/year were removed and recruitment was 10% per year the number of conchs per hectare would have meant reproductive failure (i.e. density less than 56/ha) since 1986 and the complete absence of conch since 1992 (Table 2). Given that landings and CPUE have remained stable it is very unlikely that as little as 10% of the shallow water area is conch habitat and that the fishery is in such a state.

The estimates based on 10% of the bank, however, show how much of a devastating effect fishing can have if it is all focused in a small area. Given that 2/3 of the Bahamas' population is on New Providence, it is very likely that New Providence was overfished long ago and remains in such a state.

5.8.5 Management

Although it is unlikely that the conch fishery is overfished as a whole, additional management tools are recommended due to the susceptible nature of small areas to overfishing and the uncertainty involved in fishery assessments. Management should be focused on maintaining abundance levels across all conch habitats especially with regards to avoiding serial depletions. Closed areas near population centres are warranted as a precautionary measure and for rebuilding areas that appear to be overfished.

No. of Conch per Hectare	No. minus 17 conchs per year	No. plus 10% recruitment per year	Year
200	183		1978
183	151.89	201.3	1979
151.89	126.0687	167.079	1980
126.0687	104.637021	138.67557	1981
104.637021	86.84872743	115.1007231	1982
86.84872743	72.08444377	95.53360017	1983
72.08444377	59.83008833	79.29288814	1984
59.83008833	49.65897331	65.81309716	1985
49.65897331	41.21694785	54.62487064	1986
41.21694785	34.21006671	45.33864263	1987
34.21006671	28.39435537	17.21006671	1988
28.39435537	23.56731496	11.39435537	1989
23.56731496	19.56087142	6.567314959	1990
19.56087142	16.23552328	2.560871416	1991
16.23552328	13.47548432	-0.764476725	1992
13.47548432	11.18465198	-3.524515681	1993
11.18465198	9.283261147	-5.815348016	1994
9.283261147	7.705106752	-7.716738853	1995
7.705106752	6.395238604	-9.294893248	1996
6.395238604	5.308048042	-10.6047614	1997
5.308048042	4.405679874	-11.69195196	1998
4.405679874	3.656714296	-12.59432013	1999
3.656714296	3.035072866	-13.3432857	2000
3.035072866	2.519110478	-13.96492713	2001
2.519110478	2.090861697	-14.48088952	2002
2.090861697	1.735415209	-14.9091383	2003
1.735415209	1.440394623	-15.26458479	2004
1.440394623	1.195527537	-15.55960538	2005

Table 2: Hypothetical Number of Conch per Hectare based on 10% of the fishing ground, a harvest of 17 conch/ ha/year and recruitment to the fishery of 10%/year.

Note that in 1986 reproductive failure would have occurred and thus three years after that time the fishery is treated as if no recruitment is occurring. The three-year lag corresponds to the time it would have taken for conchs to recruit to the fishery after settling out of the larvae.

Appendix 6: Report of the Shrimp and Groundfish Working Group

Chairperson: Lara Ferreira
Co-Chair: Suzuette Soomai
Rapporteurs (Shrimp): Lara Ferreira, Colletta Derrell
Rapporteurs (Groundfish): Suzuette Soomai, Pamila Ramotar
Consultants: Paul Medley, Clay Porch

A. OVERVIEW

Species to be Assessed and Data Available

Groundfish

Three species are listed for assessment (*Cynoscion virescens, Lutjanus synagris*, *Macrodon ancylodon*). Data for *C. virescens* and *M. ancylodon* were not available at this meeting.

Lutjanus purpureus is listed as one of the species to be assessed under the RSWG Working Group, however, neither the Chairperson nor the Rapporteur for this group were present at the meeting. It was decided to consider this species under the SGWG since the habitat of the species in this case is the muddy-bottom substrate associated with shrimp and groundfish fisheries of the Guianas-Brazil Continental Shelf and not a reef environment.

Guyana: *Lutjanus purpureus*
Catch and effort and length frequency data are available for 1996 to 2005 from hook and line and traps. The government of Guyana is currently considering the promotion of the use of hook and line gear over traps due to environmental concerns with regard to ghost fishing. An assessment was conducted for *L. purpureus* which looked at selectivity and parameters were determined for a YPR.

Trinidad and Tobago: *Lutjanus synagris*
Catch and effort data available for 1995 to 2004 for artisanal gillnet, line and trawl fleets and for 2000 to 2004 for the industrial trawl fleet. Some historical catch and effort data are also available from 1963 and 1975. Length frequency data are available for 1996 to 1998 for artisanal gillnet and lines. A YPR analysis using data from fish pots and trawl gear in Trinidad (Manickchand-Dass 1987) provided biological parameters, which could be used for comparison. It was noted that this resource is considered to be shared with Venezuela however no data are available at this meeting.

Shrimp

Four species are listed for assessment (*Farfantepenaeus notialis, F. subtilis, F. brasiliensis, X. kroyeri*). The rapporteur for *F. subtilis* and *F. brasiliensis*, Ms Yolanda Babb from Suriname, was not present at this meeting. However data for these two species were still submitted for analysis.

Suriname:
Monthly production, counts of individuals by commercial size categories, number of vessels and days at sea for 2000 to 2004 are available for *F. subtilis* and *F. brasiliensis.*

Trinidad and Tobago:
Catch and effort (1992-2004) and length frequency data (1992-2002) are available for all four species listed as well as *Litopenaeus schmitti*.

Guyana:
Weights by commercial size category, number of vessels and days for 1998 to 2005 for *X. kroyeri* are available.

It was agreed that with respect to Trinidad and Tobago, a previous assessment conducted of the shrimp stocks shared with Venezuela using a surplus production model could be updated. In addition discussions would be initiated regarding the development of a population model in AD Model Builder, which was one of the research recommendations coming out of the preliminary assessment of *F. notialis* and *X. kroyeri* conducted at the First Scientific Meeting in 2004. Depending on availability of time, attempts could also be made to determine growth parameters from the length frequency data using the software LFDA (Length Frequency Distribution Analysis).
With respect to Guyana, the data for *X. kroyeri* would be used to update and expand the work on a population model previously developed.
The data submitted for Suriname was considered too short a time series to attempt a worthwhile assessment at this meeting. It is known that much more data exists which can be collated and made available for assessment at a future meeting.

Recommendations/Conclusions

General

1. The CRFM should urge countries which are not members of the CRFM but with which resources are shared to attend the CRFM scientific meetings and participate in the assessments. If their participation is not possible, the CRFM should request that they submit the relevant data for analysis. The shrimp and groundfish resources are shared with other countries on the Guianas-Brazil continental shelf which includes countries which are not members of the CRFM (Venezuela, Brazil, French Guiana). Consideration should be given to networking with the FAO/WECAFC Ad hoc working Group on the Shrimp and Groundfish Resources of the Guianas-Brazil Continental Shelf.
2. Species rapporteurs must keep in contact with other country scientists during the inter-sessional period to ensure that all necessary data are available for analysis at the scientific meeting and any preliminary analyses are conducted. Species rapporteurs and country scientists should make every effort to gather and bring to the scientific meetings as much data on the fishery to be assessed including historical data and as much data as are available in as raw a form as possible (unraised) to maximize utility. In many cases the data brought to these scientific meetings are only a small portion of the data that are available. If possible, entire computerized databases can be brought to meetings.
3. Species rapporteurs should review the progress of data preparations at least every four months during the inter-sessional period so that decisions can be made with regard to which species can be assessed at upcoming scientific meetings. For species already assessed, the conduct of further analyses at the next meeting should be conditional on whether sufficient new data are available.
4. The working group need not meet every year unless sufficient new data are available to assess or update assessments. Alternatively the group can meet for only as many days as required before the plenary.

Groundfish

1. Recommendations for improving the data sets for *L. synagris* and *L. prupureus* will be addressed in the inter-sessional period. For the snappers, data and information from other neighbouring countries with fleets exploiting the shared resources, whether as a targeted fishery or taken as bycatch, must be sourced and included in future attempts to evaluate the snapper fisheries. On the national level, all attempts must be made to obtain more representative statistical coverage of gear. Data on the ageing of these snappers would also be very useful for incorporation in assessments.

2. In the absence of Suriname, who had initially recommended the placement of *M. ancylodon* and *C. virescens* on the list of species to be assessed, it was decided that the current groundfish species listed remain unchanged. However another species, *Micropogonias furnieri* (Whitemouth croaker) which is a main groundfish species in Trinidad and Tobago, will be added for future analyses. In addition, *L. purpureus* will remain as one of the species listed under the SGWG.

Shrimp

1. It is recommended that for the next meeting a joint assessment can be attempted for Guyana and Suriname. *F. subtilis* and *F. brasiliensis* were identified by Suriname as priority species for assessment at this meeting and as indicated above this was not achieved. The CRFM would need to obtain feedback from Guyana and Suriname regarding this recommendation and the identification of priority species for the next meeting. It is felt that at the very least a surplus production model for all shrimp species (as was done for Trinidad and Tobago and Venezuela) can be developed. This may require an inter-sessional meeting to prepare datasets. The species identified for analysis at the Third Scientific Meeting are the four species listed for the Second Scientific Meeting, namely *F. subtilis, F. brasiliensis, F. notialis*, and *X. kroyeri*. In addition, *Litopenaeus schmitti* would be added to the list.
2. The surplus production model for Trinidad and Tobago and Venezuela can be updated every few years. If a closed season is implemented in either or both countries the CPUE can be monitored and the model updated. The model can also be further developed to address specific management questions if required. It may be useful to include data for Guyana and Suriname in this production model.
3. Develop a species-specific population model, which would provide more detailed management advice and which could be applied to the shrimp fisheries of Trinidad and Tobago, Guyana and Suriname where length frequency data are available.
4. During the inter-sessional period Trinidad and Tobago will attempt to estimate growth parameters from the length frequency data using Length Frequency Distribution Analysis (LFDA). Morphometric relationships will also be determined.
5. Jamaica is interested in assessing their shrimp resources at a future scientific meeting as soon as the necessary data can be compiled.

B. FISHERIES REPORTS

1.0 The Atlantic Seabob (*Xiphopenaeus kroyeri*) Fishery of Guyana

Rapporteurs: Colletta Derrell, Fisheries Officer, Guyana & Paul Medley, Fisheries Consultant, UK

1.1 Management Objectives

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

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

1.2 Status of Stocks

The data are not sufficient to determine the status of the stock precisely. However, the preliminary results from the assessment indicated that the seabob fishery is fully- to over- exploited.

1.3 Management Advice

The current closed season should be moved from September to May. Empirical and theoretical results indicate that the smallest shrimp are landed in May, when the largest recruitment occurs, and therefore the most should be made of these new recruits by allowing them to grow.

The current closed season should be increased from 6 weeks to 8 weeks. The results from this assessment indicate that there would be an overall improvement in yield with increasing the length of the closed season.

A precautionary approach to exploitation should be adopted. Current fishing effort needs to be limited to current levels and will probably need to be reduced in the longer term. A longer closed season will also contribute to controlling the effective fishing mortality. The sizes of shrimp have been falling, which is consistent with a significant increase in fishing mortality detected by the stock assessment.

1.4 Statistics and Research Recommendations

1.4.1 Data Quality

Catch and effort data quality needs to be improved. Raw data records need to be reviewed and computerized, so that accurate, reliable catch and effort statistics can be produced. Some trip sampling data may also be available, but will need to be computerized to be used in assessments.

1.4.2 Research

It is strongly recommended that a biological sampling programme be initiated for at least one year to obtain seasonal changes in size, sex and maturity compositions. This information can be used to improve the assessment and verify optimal placement and length of the closed season.

1. Because the working group was unable to address the current management objectives in the draft management plan, it recommends that data collection be reviewed to identify data variables and methodology appropriate for these objectives.
2. Guyana should combine data with Suriname for a joint assessment. It is likely that the seabob stock is shared between Suriname and Guyana. This will also give an opportunity to explore simpler models, which may give more reliable management advice on stock status. It will be

necessary to reconstruct a time series particularly of total catch and, to a lesser extent, effort data, to allow the stock status to be evaluated.

3 A time series of an environmental variable to link to recruitment and stock productivity (e.g. growth rate) should be gathered to help determine past population dynamics and provide the basis for predicting future catches. This would also be useful in determining alternative management controls if required, such as individual quotas which could be allocated to the fishing industry.

1.5 Stock Assessment Summary

A virtual population analysis was carried out on the commercial size category catch data, fitted to the available effort data. Catches are reported in size categories by the fishing industry. No data were available to check the size distribution within these categories as would be provided by a biological sampling programme. Effort is measured as number of trips, but is estimated from the number of registered vessels rather than observed directly.

The catch-at-size data were converted from size to age using a growth model. No growth model parameters were available for this species in Guyana, but reasonable parameter estimates were available for this species from the scientific literature.

Once acceptable catch-at-age data are available, a standard assessment method can be applied to obtain fishing mortality (approximately the proportion of the stock being removed by fishing) and selectivity. These results were used in a yield-per-recruit.

A yield-per-recruit (YPR) account for the effective weight each new shrimp recruited to the stock contributes to the catch. It allows for the fact that shrimp are growing, so when they are caught they contribute increased weight when they are older, but that they are also dying from natural causes, so that as they get older there are also fewer of them. As the stock is fished harder, the catch tends to consist of larger numbers of younger smaller shrimp (Fig. A). This will tend to increase the yield but with diminishing returns. The YPR used the selectivity and fishing mortality estimates from the virtual population analysis.

Yield-per-recruit was used to advise on the length and timing of the closed season. Increasing the closed season delays fishing allowing the shrimp to grow. The yield-per-recruit was maximized with a closed season between 2 and 3 months. A greater proportion of small shrimp are landed in May (Fig. B). As a result, it was found that yield-per-recruit from a closure in May would provide the greatest benefit to the fishery (Figure C).

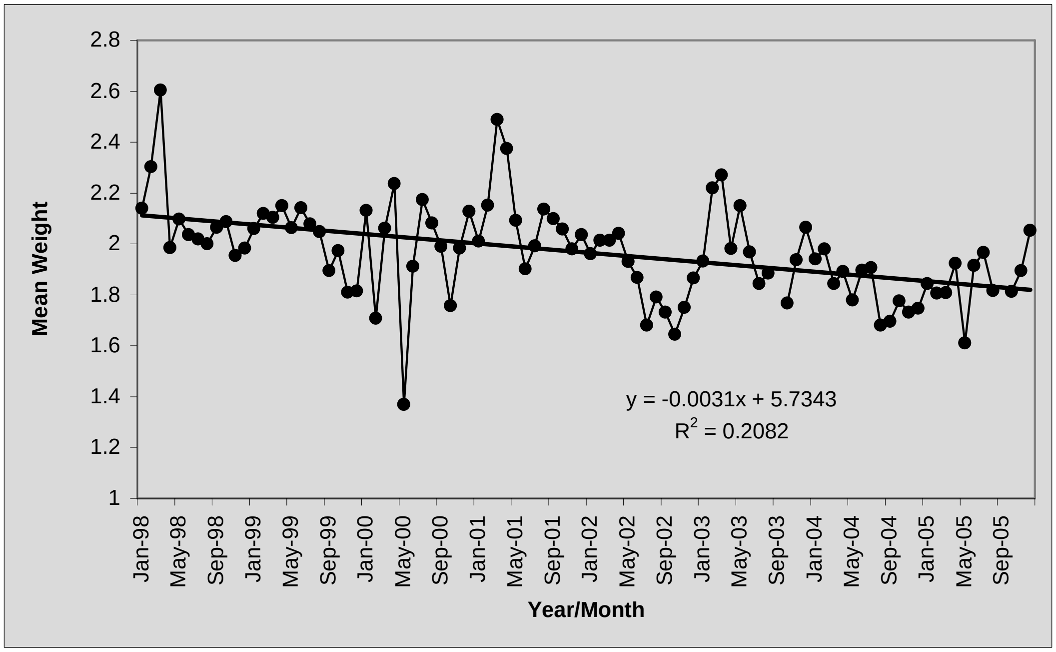

Figure A. Mean size of shrimp estimated from the commercial size composition data. The linear trend line indicates a decline in average size over the seven year period consistent with increasing fishing mortality.

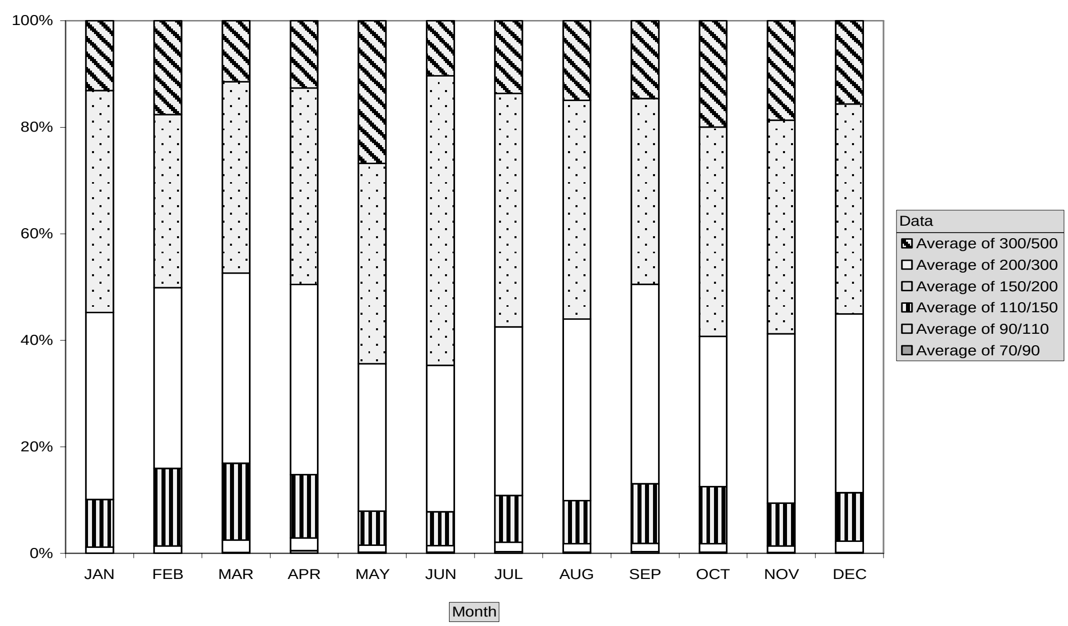

Figure B Commercial size category composition of seabob for each month as reported by the fishing industry. The smallest shrimp seem to be landed in May. There is some evidence of growth as the 300/500 category shrinks and the 200/300 category expands in June.

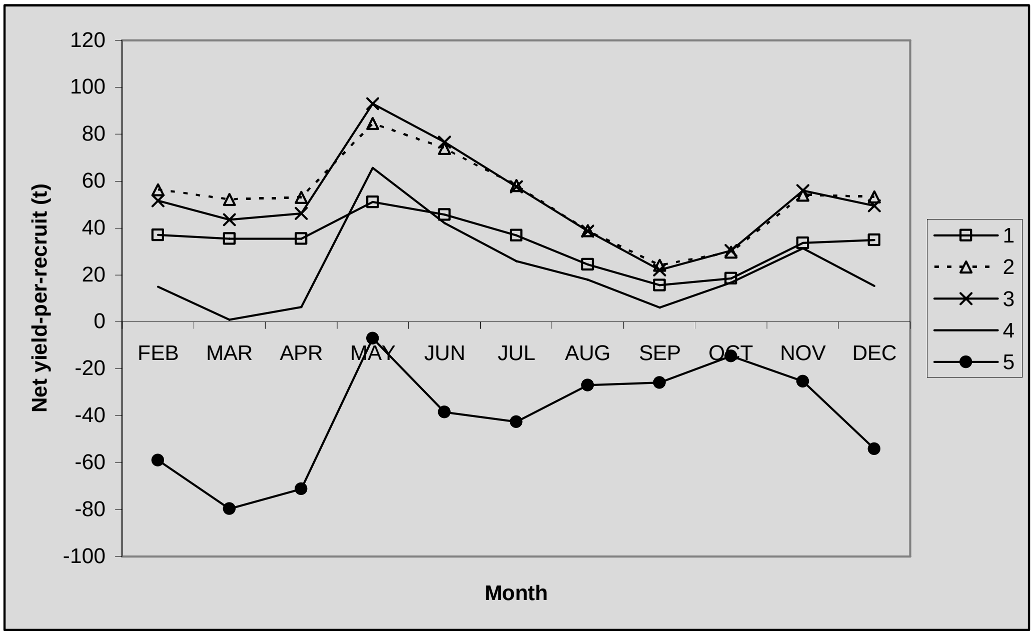

Figure C. Yield-per-recruit score for season closure in each month. A closure of 2 or 3 months gives maximum benefit, close to the current closed season in September/October of 1.5 months. It is most apparent, however, that most benefit would be obtained from a closure in May and June, when the majority of the smallest shrimp are landed.

1.6 Special Comments

The management objectives set out in the Draft Fisheries Management Plan could not be addressed because the data were not sufficient to estimate the necessary indicators. Thus, the Draft Fisheries Management Plan must be revised and/or the data being collected need to be reviewed in order to meet the management objectives.

1.7 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.

1.8 Scientific Assessments

1.8.1 Description of the offshore Seabob 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.

1.8.2 Objective

To determine the status of the seabob stock and identify management controls that can be used to sustain yields.

1.8.3 Data Used

Name	Description
Catch by size category after processing	Weights by commercial size category for each vessel trip were collected from six seabob processing companies. The data covered the period January 1998 to December 2004.
Trips per month	Estimated number of trips per month was available from a mean trips value obtained from vessel monitoring data and number of registered vessels. The exact method for estimating the mean trips was not known at the meeting.
Estimated chinese seine catches	Raised catches for those months where trip interviews took place. No size composition or effort data were available.

Data was combined to obtain total catch by size category and number of trips for each month. This required assuming that the mixed category and chinese seine was landing the same catch size composition as that reported for the sorted catch.

1.8.4 Virtual Population Analysis Assessment

1.8.4.1 Objective

The aim was to fit a virtual population analysis model to the available data to obtain selectivity and overall fishing mortality for the available time series.

1.8.4.2 Method/Models/Data

1.8.4.2.1 Life History Parameters

The proportions of shrimp at each age are distributed among the length groups using an age-length key generated from a growth model (see next section) using assumed life history parameters (Table 1). The age-length key can conversely be used to convert from length back to age by redistributing the length sample among ages based upon these proportions. The spread of proportions indicate the uncertainty in converting from length to age and is provided as an additional parameter.

Catches are converted from weight to numbers and the yields are calculated using the length-weight relationship. The original length-weight relationship obtained from Trinidad (Lum Young *et al*. 1992) was not compatible with the assumed size composition within the commercial categories and the growth model. Therefore the length-weight exponent (b) was fixed at 3 and scale parameter (a) varied to find reasonable results (see

1.8.4.4 Results

The growth parameters as well as the recruitment age could, in theory, be adjusted within the model to obtain the best possible fit to the model. However, the data was not sufficient to allow these parameters to be estimated in this case.

	X. kroyeri	Source
L_∞ (carapace length)	32.87 mm	Flores Hernandez *et al*. (2002) as the mean between the male and female weighted by the reported sex composition.
K	0.082 month^{-1}	
t_0	0.0945 months	
M	0.183 month^{-1}	
A	0.0011 g mm^3	No Source. *b* was set at 3.0 and *a* was scaled to ensure the catch weight composition was within the growth model range.
B	3.0	
Sigma	0.04	No source. Variability of size at age set to a coefficient of variation of 4%. A lower value implies the size composition is informative on age.

Table 1. Input parameters to the catch-at-age model.

1.8.4.3.1 Construction of the Age-Length Key

The age length key is a matrix of probabilities. Each cell in the matrix is the probability that a fish is within the age and size class defined. It is calculated from the joint log-normal distribution where the mean is given by the age at length from the deterministic von Bertalanffy growth model. The probability is then apportioned to discrete age and size classes by integration.

$$P(c) = \int_{a_c}^{a_{c+1}} \int_{s_c}^{s_{c+1}} N(a, s | \mu, \sigma)\, ds\, da \qquad (1)$$

where $P(c)$ = probability that a shrimp is in class c with size and age lower and upper limits as s_c, s_{c+1}, a_c, a_{c+1} respectively. The mean log-length at age is given by the log of the von Bertalanffy growth curve:

$$\mu_a = \ln(L_\infty) + \ln\left(1 - e^{-K(a-t_0)}\right) \qquad (2)$$

where a is the age, and L_∞ , K and t_0 are the standard von Bertalanffy growth parameters. Other probability distributions besides the log-normal could be used, but the log-normal is convenient and assumes the variance in length increases with age, which is likely.

The proportion of fish of a particular age in any length class were calculated as the difference between the cumulative normal distribution of the two log-length class boundaries. This function is available in MS Excel (*NormSDist((x-μa)/σ)*). This represents the inner integration in equation (1). A numerical approximation to the integral (Simpson's rule) over one year's aging was applied to approximate the outer integral in equation (1). So the proportion of cohort age a in length class i (p_{ai}) was calculated as:

$$\begin{aligned} p_{ai} = \tfrac{1}{2}\Big[&\big(\mathrm{N}(\ln(l_{i+1}); \mu_a, \sigma) - \mathrm{N}(\ln(l_i); \mu_a, \sigma)\big)/3 \\ &+ \big(\mathrm{N}(\ln(l_{i+1}); \mu_{a+0.5}, \sigma) - \mathrm{N}(\ln(l_i); \mu_{a+0.5}, \sigma)\big)\, 4/3 \\ &+ \big(\mathrm{N}(\ln(l_{i+1}); \mu_{a+1}, \sigma) - \mathrm{N}(\ln(l_i); \mu_{a+1}, \sigma)\big)\, /3\Big] \end{aligned} \qquad (3)$$

where N( ) is the cumulative normal distribution, l_i is the lower limit for length class i. The probability that a shrimp is in any particular age group, given its length class, is calculated as the probability (equation 3) normalized by the sum of probabilities over the age groups for this size. That is, we know the shrimp is in this size group, but the age group remains unknown. The rows of probabilities for each length class can be combined into a matrix. A row of catches at length can then be converted to catches at age by matrix multiplication:

$C_{lt}\, P = C_{at}$ (4)

where C_{lt} = Catch-at-length row vector for a particular month, P= the age-length key matrix which has rows summing to 1.0, and C_{at} = the catch-at-age row vector resulting from the conversion.

1.8.4.2.2 Fitting the Population Model

A separable VPA approach is used to fit the catch-at-age model. This and similar models and software are described by Lassen and Medley (2001).

Fitting takes place at two levels. Firstly, the population model is fitted using the available catches assuming they and the natural mortality rate are known exactly. This leaves a single parameter to fit for each cohort, which in this case is the initial recruitment rather than the "terminal F", although the result is the same. At the higher level the selectivity parameters are fitted to the "observed" fishing mortality from the population model using the observed fishing effort.

$$
\begin{aligned}
P_1 &= P_0 e^{-M} - C_0 e^{-0.5M} \\
P_2 &= P_1 e^{-M} - C_1 e^{-0.5M} = \left(P_0 e^{-M} - C_0 e^{-0.5M}\right) e^{-M} - C_1 e^{-0.5M} \\
&= P_0 e^{-2M} - C_0 e^{-1.5M} - C_1 e^{-0.5M} \\
&\vdots \\
P_a &= P_0 e^{-aM} - \sum_{t=1}^{a} C_{t-1} e^{-(t-0.5)M}
\end{aligned}
\qquad (5)
$$

and in natural logarithm terms

$$
\Pi_a = Ln(P_a) = Ln\left(e^{-aM+\Pi_0} - \sum_{t=1}^{a} C_{t-1} e^{-(t-0.5)M} \right) \qquad (6)
$$

$$
LnF_a = Ln(\Pi_a - \Pi_{a+1} - M)
$$

The aim is to find an initial population that will minimise the squared difference between the log fishing mortalities from the population model and the log fishing mortalities estimated from a selectivity curve and effort data.

$$
L(\Pi_0) = \left(Ln(q_a f_t) - LnF_a\right)^2 \qquad (7)
$$

$$
\frac{dL}{d\Pi_0} = -2\left(Ln(q_a f_t) - LnF_a\right) \frac{dLnF_a}{d\Pi_0} \qquad (8)
$$

and the second derivative can be approximated by

$$
\frac{d^2 L}{d\Pi_0^{\,2}} \approx 2\left(\frac{dLnF_a}{d\Pi_0}\right)^2 \qquad (9)
$$

$$\frac{d^2L}{d\Pi_0^{\ 2}} = \{\Pi_0\}_{old} - \left[\sum_{a=0}^{A}\left(Ln(q_a f_t) - LnF_a\right)\frac{dLnF_a}{d\Pi_0}\right]\left[\sum_{a=0}^{A}\left(\frac{dLnF_a}{d\Pi_0}\right)^2\right]^{-1}$$

$$P_a\left(1-e^{-Z_a}\right) = \frac{C_a Z_a}{F_a} = C_a\frac{M}{F_a} + C_a \qquad (10)$$

and, again based upon Pope's approximation,

$$P_a\left(1-e^{-Z_a}\right) \approx P_a\left(1-e^{-M}\right) - C_a e^{-0.5M} \qquad (11)$$

and by substitution and rearranging, we get:

$$C_a\left(1+\frac{M}{F_a}+e^{-0.5M}\right) + \left(1-e^{-M}\right)\sum_{t=1}^{a} C_{t-1}e^{-(t-0.5)M} = P_0\left(e^{-aM} - e^{-(a+1)M}\right) \qquad (12)$$

Given the fishing mortality at each age (F_a), the left hand side is determined for each age in a cohort and can be used as the dependent variable in a regression. The recruitment for the cohort (P_0) can be estimated using least-squares as:

$$\hat{P}_0 = \frac{\sum_a\left(C_a\left(1+\frac{M}{F_a}+e^{-0.5M}\right) + \left(1-e^{-M}\right)\sum_{t=1}^{a} C_{t-1}e^{-(t-0.5)M}\right)\left(e^{-aM} - e^{-(a+1)M}\right)}{\sum_a\left(e^{-aM} - e^{-(a+1)M}\right)^2} \qquad (13)$$

This estimate is then further refined using a Newton-Raphson algorithm and the catch equation rather than Pope's approximation.

1.8.4.3.4 Link Model

The link model connects the population model to the observations, in this case fishing effort. A separable VPA model was used to divide up the sources of fishing mortality into the exploitation rate (effort) and selectivity at age. The expected effort can be calculated from the model as:

$$E\left(\ln(f_t)\right) = \ln(F_{at}) - \ln(S_a) \qquad (14)$$

where S_a is the selectivity at age. The model can then be fitted by minimizing the squared difference between the observed and expected log-effort, thereby obtaining the log-normal maximum likelihood estimates. The results should be very similar to fitting *ln (CPUE)* to the log population size. The fishing mortality model should be better than fitting CPUE to population size, where the fishing mortality (i.e. effort) is very high within a month.

The model was fitted in a spreadsheet. The least squares (log normal maximum likelihood) estimates for selectivity can be found directly through calculation. The selectivity is simply the difference between the average log fishing mortality (at age) and the average log effort for each age. The remaining parameters were found using Solver add-in software in MS Excel.

There were a number of cohorts to which the model failed to fit. For these, the model resorts to a standard VPA, where the terminal population is close to zero (one animal survived beyond 25 months) and the population is back-calculated using the assumed natural mortality.

1.8.4.4 Results

The model did not fit the data very well and this contributes to the uncertainty in interpreting the results. The model failed to fit a number of cohorts, probably due to a combination of inaccuracies associated with the conversion of size to age, and the poor effort data. However, the VPA should still be able to capture patterns in the size composition data and fluctuations in catch.

The primary result was the selectivity pattern which has a significant impact on the yield-per-recruit (Figure 1). The pattern suggested asymptotic selectivity with 50% selectivity at around 12 months old (age is dependent on the growth model). As long as the same growth model is used, this selectivity can be used in a yield-per-recruit model.

Given the uncertainty and lack of a stock recruitment relationship, it was not possible to determine the status of the stock against a reference point. However, assessment results suggest fishing mortality has been increasing since 1998 (Figure 2). This pattern is confirmed by the decreasing mean size (Figure 3). Recruitment shows no clear pattern (Figure 4), but it is likely that seasonality in the population dynamics is being obscured by correlating factors, specifically seasonal patterns in fishing activity and the broad size classes used for reported landing size composition.

Model results are very sensitive to the life history parameters. Life history parameters, where possible, were obtained from scientific literature, but their accuracy is unknown. In addition, it was found that parameters from different sources are not necessarily consistent. Growth parameters from a publication were used, but the length-weight and growth variability (sigma) parameters had to be set to reasonable values to obtain realistic results. This of course means that the quantitative parameter estimates produced by the model (selectivity and overall fishing mortality) are unreliable. This should not affect the qualitative results, which should be dependent on general patterns in the data, such as changes in size composition. However, conclusions will need to be supported by direct empirical evidence, which does not depend upon the growth or length-weight models.

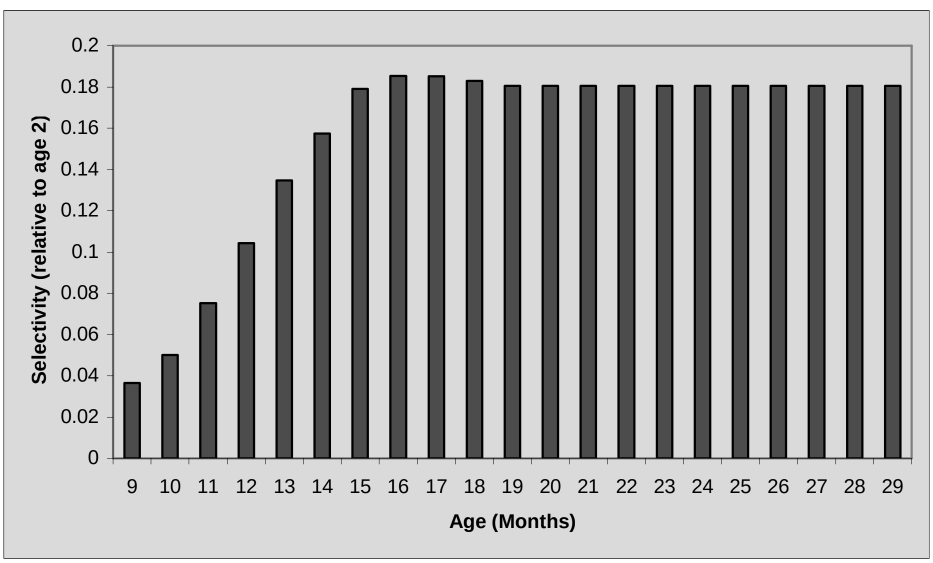

Figure 1. Selectivity estimated from the separable VPA. The selectivity was forced to have an asymptotic shape, so age 19 months onwards had a fixed selectivity (only one parameter was estimated), which resulted in a very small loss to the log-likelihood and represents a pattern close to the fully estimated selectivity (all ages have an independent estimated parameter). Estimating all selectivity resulted in aberrant behaviour of age 29.

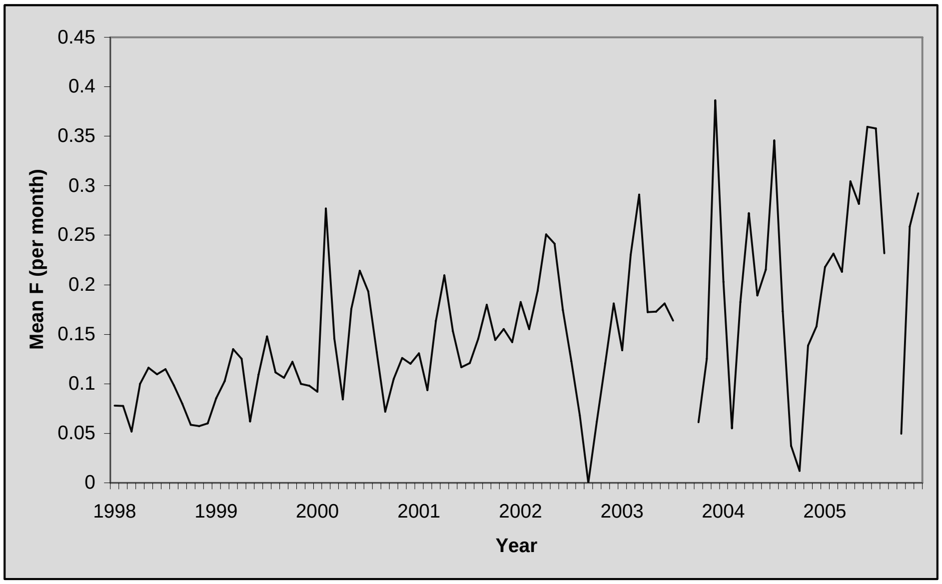

Figure 2. Mean fishing mortality (F_{mean} - geometric mean fishing mortality ages 9-29) in each month estimated by the VPA. The results show an upward trend in fishing mortality, which is supported by increased catches and decreasing mean size evident in the data (Fig. 3).

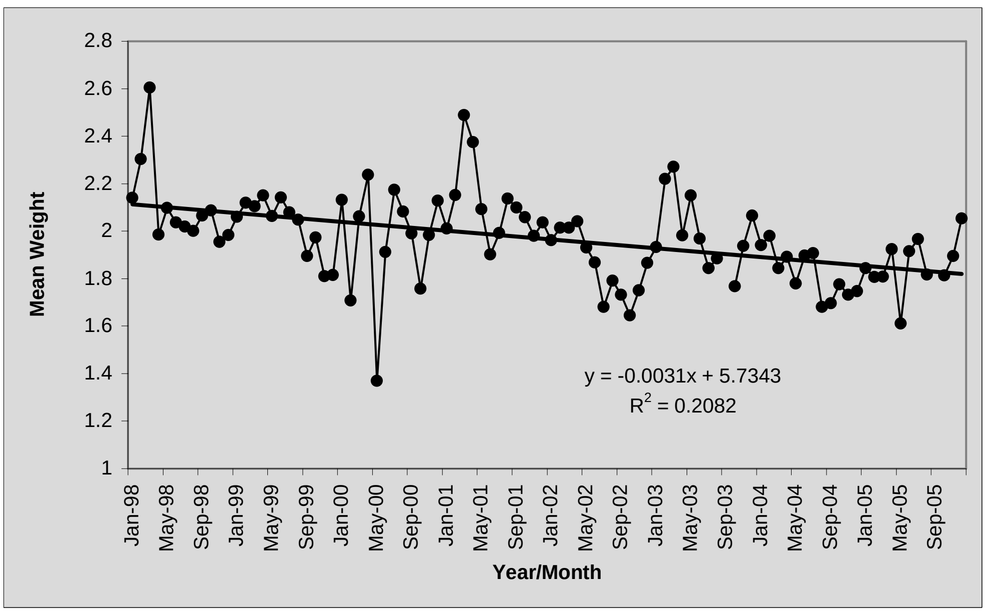

Figure 3. Mean size of shrimp in each month estimated from the commercial size category landed weights. In general, shrimp being caught are getting smaller, which implies fishing has probably been increasing throughout this period.

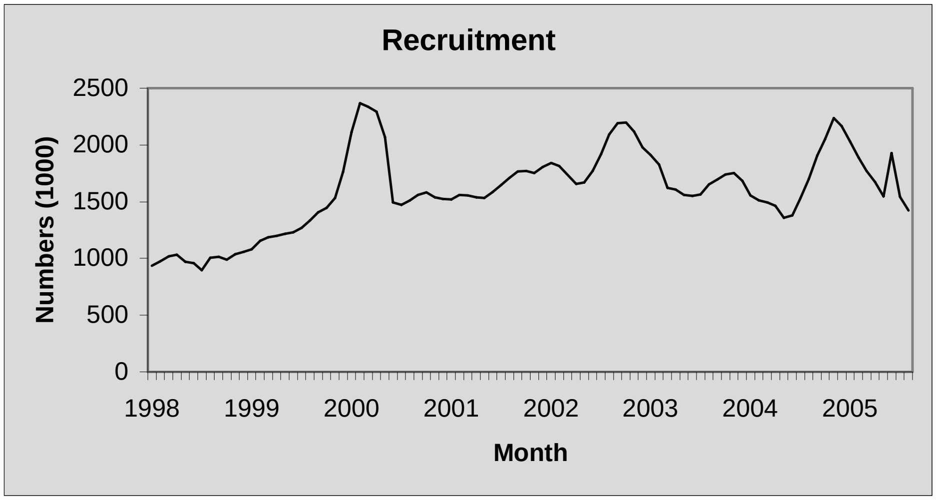

Figure 4. Estimated recruitment in each month. It is very likely that there is seasonal recruitment, which can be seen from the size compositions. There is some evidence of within year recruitment fluctuations, but a clear seasonal pattern has been smoothed out. The precision of the commercial size classes is poor, which would obscure such patterns. In addition, it is possible that some reported catches contain significant errors.

1.8.4.5 Discussion

The model cannot give reliable quantitative results. However, general qualitative patterns can be identified and used for management advice. Improving the assessment would be necessary if the assessment was used to set quantitative controls, such as catch quotas.

There is good evidence that the increasing fishing mortality coincides with the increasing number of vessels and fishing activity. Without a clear indication of what the status of the stock is, any increase is not precautionary and could lead to significant economic and ecological loss. A clear recommendation is therefore to stabilize fishing mortality (number of vessels) and allow no further increases until a reliable assessment is completed.

At least one year's sampling of the catch carapace lengths and weights stratified by the commercial size category could provide excellent information and fill out information gaps needed to fit the current model. As shrimp grow to their maximum size over one to two years, monitoring size compositions within a year should be adequate to obtain growth rates and a length-weight relationship consistent with one another. This would make the current population model much more reliable.

The other issue that requires attention is the development of a good population index. Currently the recording of fishing effort appears poor, so the index used to fit the model is unreliable and seems to fail to fit in some months. It is likely that better measures of effort can be inferred from records kept by the fishing companies.

1.8.5 Yield-per-Recruit Analysis

1.8.5.1 Objective

To provide information on the state of the fishery, with particular emphasis on offering advice on the location and length of the closed season.

1.8.5.2 Method/Models/Data

A yield-per-recruit analysis was undertaken using the selectivity parameters estimated from the VPA (Figure 1). As well as doing a standard yield-per-recruit, an empirical approach using the reported catches was used to minimize the modeling assumptions.

The principle of the empirical approach was to use actual reported catch compositions and estimate the expected yield of those catches had they not been caught at that time. It is known these shrimp would have been present in the population, so no recruitment or population sizes would have had to be assumed. For any particular catch size composition, the yield can be derived from the growth and mortality models:

$$Y_i(c) = n_i \sum_{j=0}^{\infty} W_{\infty}\left(1 - e^{-K(t_i+c+j+0.5)}\right)^b e^{-\sum_{l=0}^{j-1} F_{il}} e^{-M(c+j)} \frac{F_{ij}}{F_{ij}+M}\left(1 - e^{-F_{ij}-M}\right)$$

where Y_i = the yield from the i^{th} size class, n_i = number of shrimp and t_i = the age of shrimp in the i^{th} size class, c = length of closure in months, j = number of the month after t_i+c when fishing starts, W_{∞} = asymptotic weight, K = growth rate, b = length-weight relationship exponent, F_{ij} = fishing mortality in month i and M = natural mortality. Where economic discounting is used, M becomes natural mortality plus the discount rate.

The fishing mortality can be defined based on selectivity at age (Figure 1) and fishing effort (assuming fishing mortality is proportional to effort):

$$F_{ij} = S[t_i + c + j]\, f$$

where f = fishing effort and $S[t_i+c+j]$ = selectivity for the age of the shrimp.

To represent a closed season, fishing can be delayed by c months. By comparing a particular closed season with no closed season (c=0), we can estimate the improvement in yield. For any catch broken down by commercial size category in any month, a score for each possible closed season can be calculated by summing the change in yield across all size categories:

$$Y(c) = \sum_i Y_i(c) - Y_i(0)$$

1.8.5.3 Results

Although it is not possible to estimate the state of the stock, the yield-per-recruit suggests that the current fishing mortality and selectivity places the fishery close to the maximum yield (Figure 5). That is, even if recruitment remains unaffected, increases in yield will diminish with increasing effort. There is no information available to indicate whether diminishing economic returns would lead to falling profitability of the fishery.

The optimal length of closed season determined from the net yield method described above was found to be 3 months (Figure 6). Given the uncertainty over the growth model and other model parameters, it may be that the estimate is not considered reliable enough to accurately determine the optimal season length.

It was found that the net yield from a closed season has increased over the period monitoring has taken place (Figure 7). This is consistent with the increasing fishing mortality (Figure 2) and decreasing mean size (Figure 3) already observed.

The most important finding was the relative time of the season closure, which appears to maximize net yield in May (Figure 8). Lowest benefit occurs in September and October, when the current closed season is implemented. The maximum net yield from closure coincides with the month when the smallest size categories form the largest proportion of the catch (Figure 9).

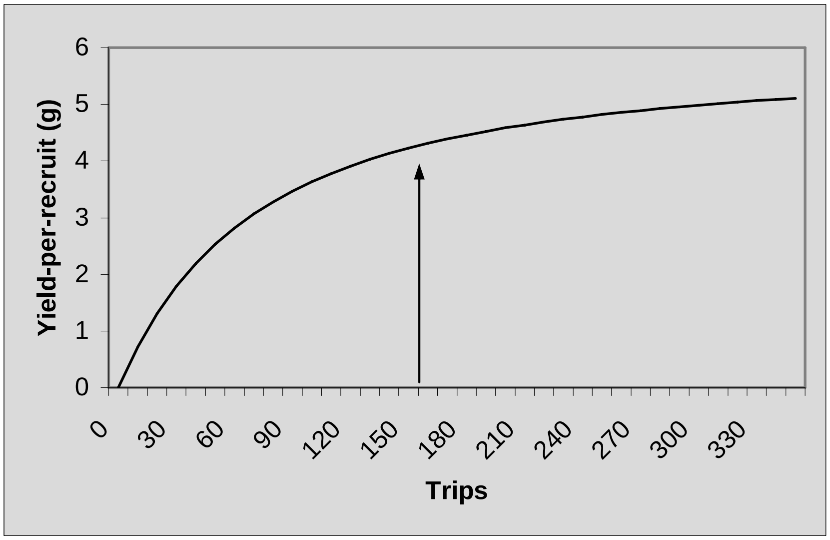

Figure 5. Yield-per-recruit based on number of trips per month, which was related to the approximate fishing mortality in the model. The current trips per month (marked by the arrow) indicate that little more yield can be obtained by increasing the fishing effort.

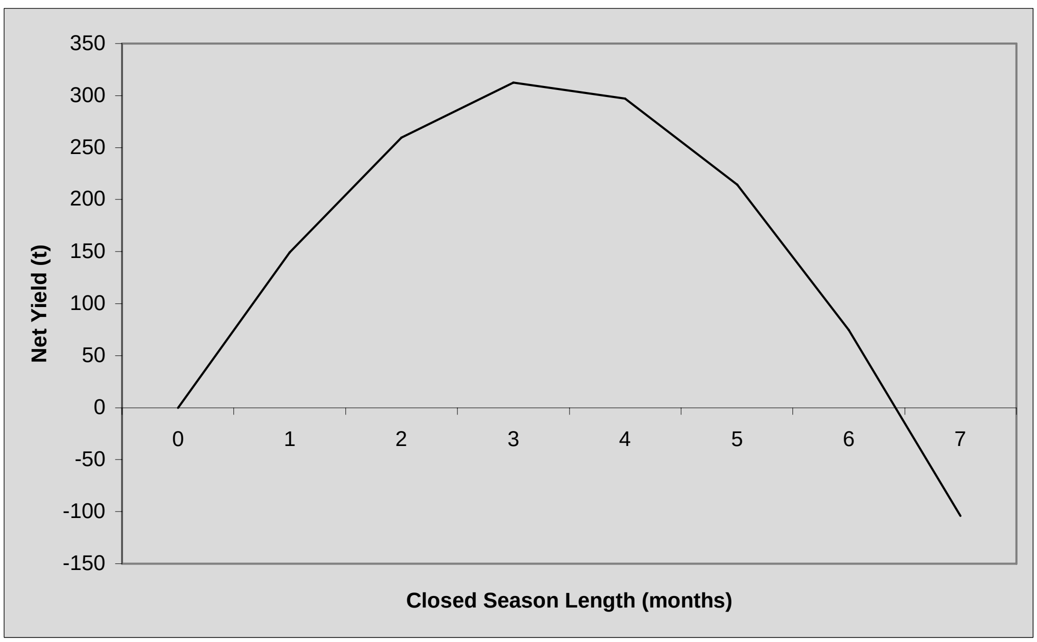

Figure 6. Average net increase in yields estimated for closed seasons of different lengths. The current closed season of 1.5 months appears to be better than no closed season at all, but the assessment suggests 3 months would realize maximum benefits. Given the uncertainties the optimal closed season length cannot be specified exactly, but a short increase from 1.5 to 2 months would be justified if the catches were carefully monitored.

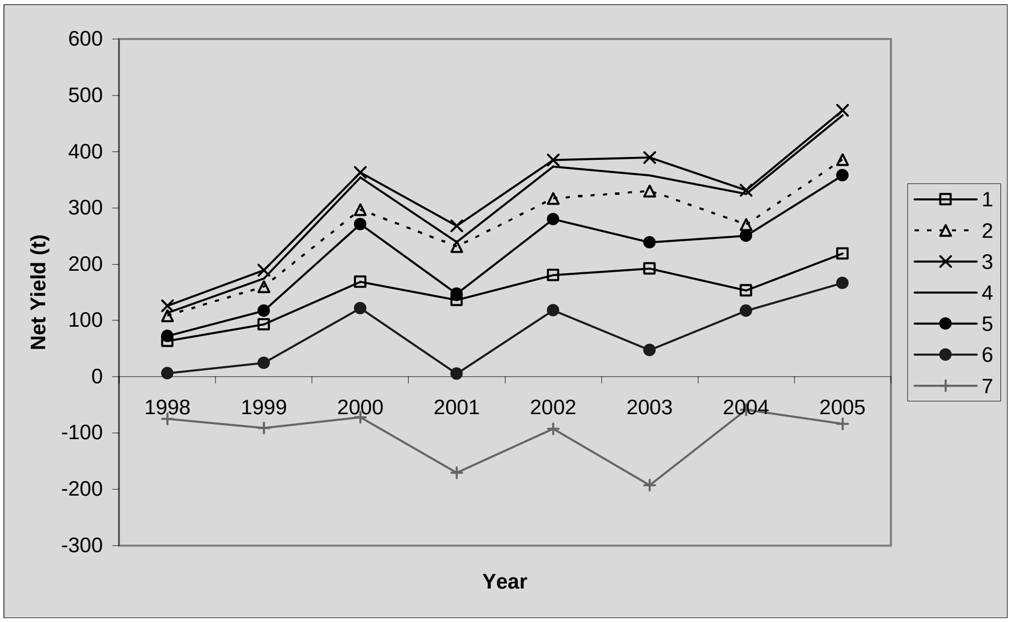

Figure 7. Average net increase in yields estimated for each year (averaged over months) for different lengths of season from 1 to 7 months. There is an increasing benefit for all closed season lengths, except 7 months. This is consistent with decreasing average size of shrimp (Figure 3), so there are increasing benefits from leaving the shrimp to grow.

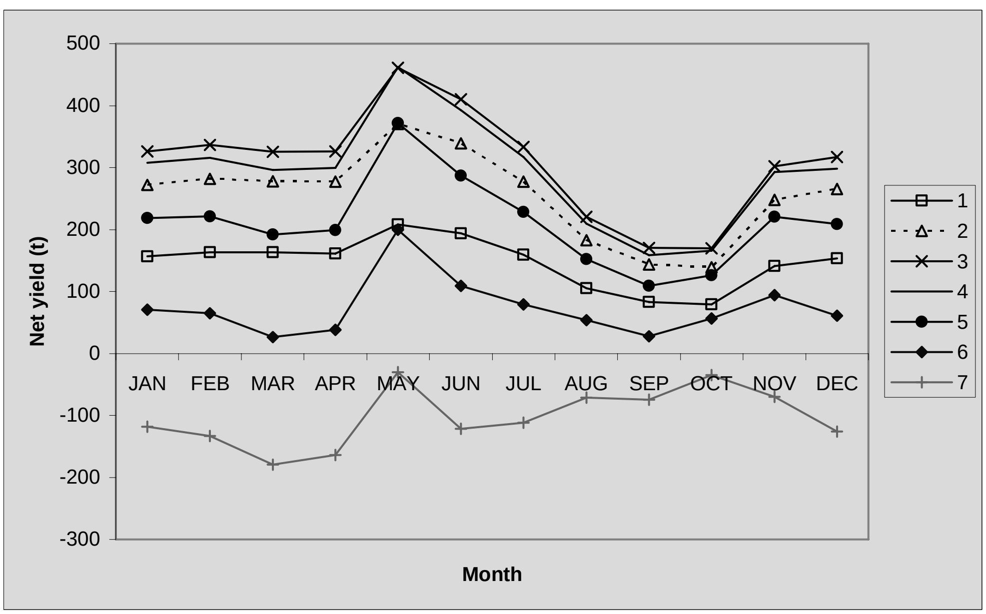

Figure 8. Average net increase in yields estimated for each month (averaged over years) for different lengths of season from 1 to 7 months. The current closed season runs through September-October, which gives the lowest improvement in yield. In all cases, a closed season starting in May gives the maximum increase in yield, with 3 and 4 month closed season giving very similar results.

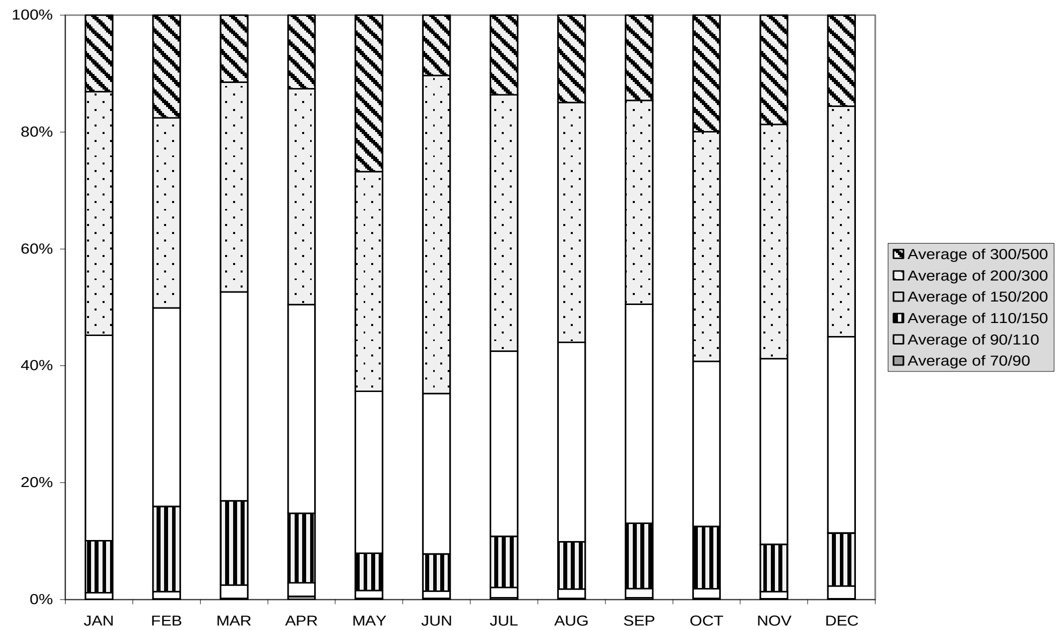

Figure 9. Size composition of landings in each month. There is a distinct increase in small shrimp in May, the most likely time of recruitment to the fishery.

1.8.5.4 Discussion

Results would suggest allowing further increases in fishing effort could adversely affect the fishery, very significantly if recruitment falls. While there is not enough information to define a reference point for the yield-per-recruit, the results suggest further increases in yield will be small. Against this must be considered the risk of recruitment overfishing as well as diminishing economic returns. Reliable reference points would require greater confidence in the growth model and some indication of maturity, spawning and fecundity, all of which could be obtained from biological sampling of the catches.

There is a noticeable increase in 200/300 size category and fall in the 300/500 size category between May and June (Figure 9). This presumably represents growth. Given that growth looks to be very rapid for this species, it should be possible to get reasonably good estimates of the growth rate parameter from monitoring the detailed size composition (carapace lengths) of landings from May to September.

It is still possible to give definite management advice on actions, which can increase yield even without stock status. It was determined that the main action of interest of a closed season. A closed season is already implemented voluntarily by industry, but it does not appear that the closed season is well founded scientifically.

The closed season is clearly not designed to protect small shrimp, but most likely the months with the lowest catch rates was chosen by the fishing companies to co-operatively reduce operating costs. This initiative can and should be built on. Not fishing in May is probably not immediately obvious as the best action because, with the new recruits, catch rates may well be highest at this time of year. However, allowing these new recruits additional time to grow will not only most likely increase yield, but also help protect the spawning stock therefore reducing the chance of recruitment overfishing. Therefore this action, changing the closed season to two months in May and June, is strongly recommended.

Although yield should increase, it cannot be certain by how much until the action is tried. Any such action as moving the closed season should be carefully monitored to ensure it has the desired affect. One reason, for example, why yields may not increase as much as expected is if there is density dependent growth. Leaving the full cohort of shrimp without “thinning” the population may make it harder for the shrimp to find food, slowing their growth. Such unknown factors require data to estimate whether they are significant.

Because the selectivity will probably mean the catches under-sample the smaller size classes, the benefits from a closed season are probably underestimated. If selectivity was not progressive, but knife-edged, smaller shrimp would be much more common in the catches. The score would show an overall increase in net yield, but whether this would greatly affect the results in terms of management advice would have to be tested through simulation.

1.9 References

Flores Hernandez *et al*. (2002) Ecologica y dinamica poblacional del camaron siete barbas *Xiphopenaeus kroyeri* (Heller, 1862) de la Laguna de Terminos, sur del Golfo de Mexico.

Lassen H. and Medley P. (2001). Virtual population analysis. A practical manual for stock assessment. *FAO Fisheries Technical Paper,* **400**. FAO, Rome.

Lum Young, P. L.Ferreira and L. Maharaj (1992) Morphometric relationships for five species of Western Atlantic tropical shrimp occurring in the Trinidad and Tobago trawl fishery. Tech Rep. FAO/UNDP: TRI/91/001/TR13 "Establishment of Data Collection Systems and Assessment of the Fisheries Resources". 31p.

2.0 The Shrimp Fisheries Shared by Trinidad & Tobago and Venezuela

Rapporteurs: Lara Ferreira, Fisheries Officer, Ministry of Agriculture, Land & Marine Resources, Trinidad & Tobago, and Paul Medley, Fisheries Consultant, UK

2.1 Management Objectives

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

2.2 Status of Stocks

The overall shrimp stock is overfished relative to the MSY. The stock biomass is declining. Current catches probably cannot be maintained in the long term.

For many of the years since 1988, the shrimp catches have been unsustainable with landings being greater than the estimated MSY. The biomass at the MSY is estimated to be half of the unexploited biomass, and the biomass since 1988 has been below the biomass at MSY and declining steadily to the current time.

2.3 Management Advice

The target sustainable yield should be between 1583 and 1905t to avoid overexploitation. It is recommended that new fishing controls be introduced (in both Trinidad and Tobago and Venezuela) to decrease the total number of days at sea permanently in order to allow the stock to rebuild. Two such controls are recommended below followed by two general recommendations for the management of the trawl fishery.

(1) Implement a closed season for trawling. Projections for the catch per day and annual catch per vessel were explored under a range of scenarios including: no change; 2% increase in effort per year; and a closed season ranging from one month (January) to four months (November to February) (Figures 1 and 2). The months for a closed season should be those when the greatest percentage of small shrimp is landed. The results suggest that there could be considerable benefit from rebuilding the stock. The disadvantage is that there will be an initial loss to the fishery during the rebuilding process (Figure 1).

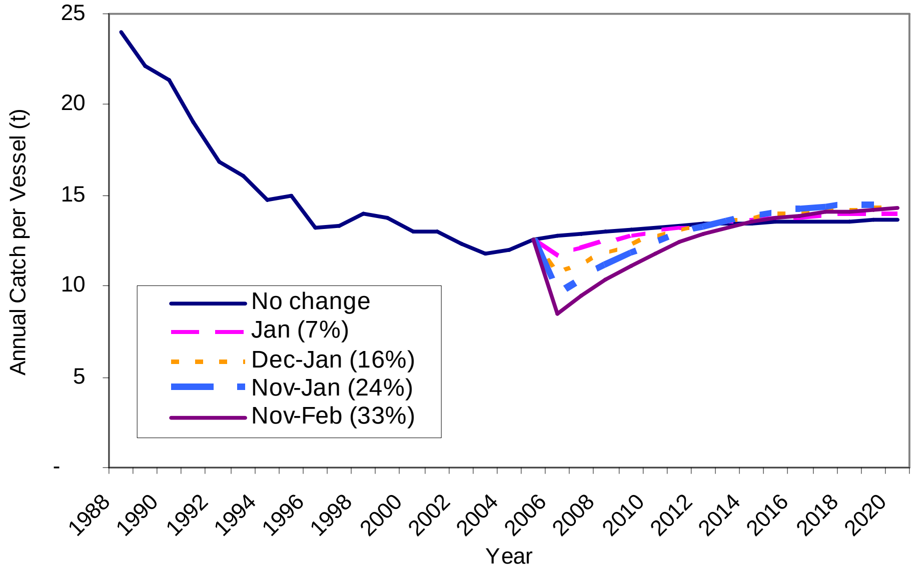

Figure 1. Estimates of the impact of implementing different closed seasons on the average shrimp catches for a representative reference vessel. The total catches and therefore annual earnings from a vessel will show an initial dip, but this should be followed by a longer term recovery increasing above the "no change" trajectory after 6 years.

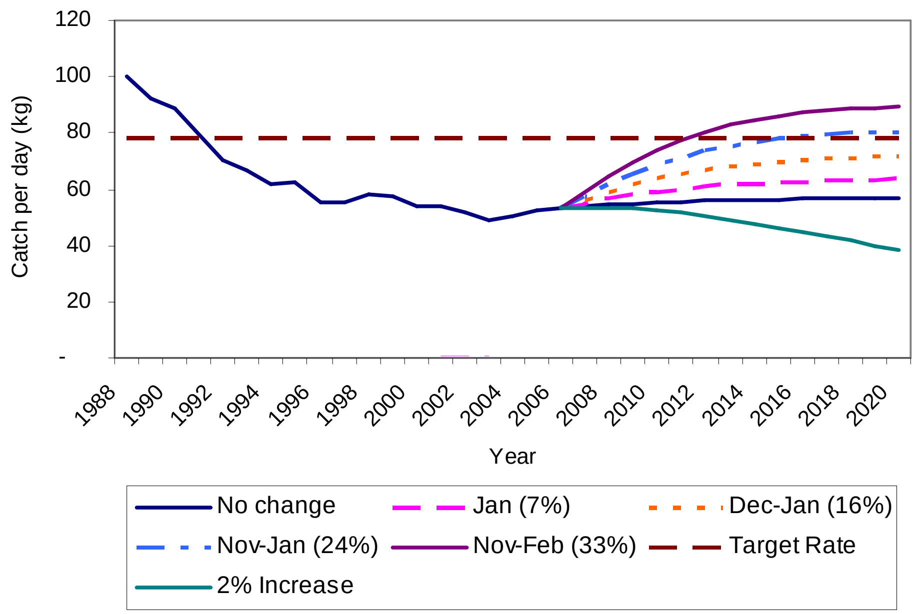

Figure 2. Projected catch per unit effort changes under different management actions. The target rate is the catch per day at the MSY. The model indicates that maintaining the current fishing effort will maintain the "status quo" and allowing effort to increase, will result in a fall in CPUE and hence a decrease in vessel earnings. Closures of one to four months should bring about a recovery.

The following activities are recommended as part of the groundwork in implementing a closed season:

- Investigate the social and economic implications of the closed season option.
- Prepare a strategy in consultation with the stakeholders as to how the closed season option should be implemented. This may include compensation or alternative employment opportunities for fishers during the closed season.

(2) Limit the numbers of trawlers with a view to reduction in fleet size:

- Update fisheries legislation to facilitate a limited entry fishery
- Implement a licensing system for trawlers

(3) Strictly enforce the current regulations for the trawl fishery as this will contribute to the sustainability of the stocks. The Fisheries [Control of Demersal (Bottom) Trawling Activities] Regulations 2001 specify a minimum cod-end mesh size as well as areas of operation including a zoning regime in the Gulf of Paria according to trawler type.

(4) Set appropriate and specific reference points for the fishery, that is, constraints within which the fishery must operate, since the management objectives for this fishery outlined in the policy document and management plan are very broad. Key issues to be considered are how the fishery will be monitored and how and what controls can be applied to affect the performance. This should be addressed through discussions among all stakeholders.

It should be noted that this analysis assumes the decline is due to fishing alone. During consultations, while accepting overfishing has a role, stakeholders have indicated that pollution from the oil industry may also have contributed to the decline in shrimp biomass. This implies that estimates of recovery may be over-optimistic, but may only be determined once management has reduced fishing mortality.

2.4 Statistics and Research Recommendations

2.4.1 Data Quality

(1) Review historical records and consult with Trinidad industrial trawl fleet operators in an attempt to verify or refine shrimp catch estimates prior to the year 2000 when sampling of this fleet was very low or non-existent. Since this fleet takes a large proportion of the total catch, poor estimates will add considerably to the uncertainty of the assessment.

(2) Continue and complete computerization of the Trinidad historical catch and effort data from the 1950s to the present. The 1975 base year was important in estimating the unexploited state and hence MSY and the current state of the stock.

(3) Obtain more detailed information, including on species life history, to account for other factors affecting productivity, such as pollution, which was suggested as a contributing factor by stakeholders.

2.4.2 Research

(1) Develop a species-specific population model which would provide more detailed management advice. Activities would include developing software, improving growth parameter estimates and morphometric relationships, and developing time series of environmental variables, including levels of pollution. This model will provide the basis to address the concerns of stakeholders as it would be able to include pollution effects. Some progress has been made on this research area.

(2) Determine growth parameters from the Trinidad shrimp length frequency data using such software as Length Frequency Distribution Analysis (LFDA). This was begun at the meeting and should be continued during the inter-sessional period. These parameters will be input for the model in (1) above.
(3) Refine morphometric relationships for input to population model in (1) above. This activity is currently in progress and should be continued during the inter-sessional period.
(4) Re-run the current model to provide better estimates of parameters. If management action is introduced resulting in a reduction of the fishing mortality, the recovery in CPUE should improve the model's ability to detect the state of the stock and predict optimum management actions. No other special action, apart from implementing the recommended management controls, will be needed.

2.5 Stock Assessment Summary

The assessment used the simplest biomass dynamics model, which provides advice on a limit reference point, the MSY. This limit reference point can be used to restrict the risk of unsustainable fishing to an acceptable level. All shrimp catches from the Trinidad and Tobago and Venezuela trawl fleets were treated as a single stock in the model since the group felt unable to disaggregate Trinidad catches by species accurately. The assessment is an update of that conducted under the FAO/WECAFC ad hoc Working Group on Shrimp and Groundfish Fisheries of the Guianas-Brazil Continental Shelf.

The model requires a complete series of catch data and as long a series of catch-per-unit effort (CPUE) data as possible. Total catches for the period 1988 to 2004 had to be reconstructed from various sources, and two possible time series of catches were used to check the robustness of the procedure to estimate catches. CPUE data were provided for four Trinidad trawl fleets and two Venezuela trawl fleets.

Additional information was necessary to determine the state of the stock in 1988 when the population model was started. It is known that the stock was relatively lightly fished in 1975, with an approximate total catch around 600t. This was used to estimate the approximate stock state in 1975, which helps to provide a useful reference point, the expected CPUE when the stock was only lightly fished.

The Trinidad Type IV (industrial) fleet index was not used since only part of the series (2000-2004) was considered reliable (as sampling of this fleet prior to 2000 was poor or non-existent) and this part has no trend in common with the other indices. As such only using this period does not make any difference to the fit.

A reasonable fit for the model was obtained with relatively stable results. The general results indicate the state of the stock is well below MSY and the current fishing mortality is causing the stock to continue to decline. The biomass appears to have consistently declined since 1988 (Figure 3). The MSY is in the region of 1700t and catches higher than this will not be sustainable. Rebuilding the stock could realize 35-80% increase in the current catch rate, while making the same catch as currently being landed. A benchmark vessel obtaining a catch per day of 105kg in 2005 could obtain a catch per day of 156 kg at MSY (49% increase).

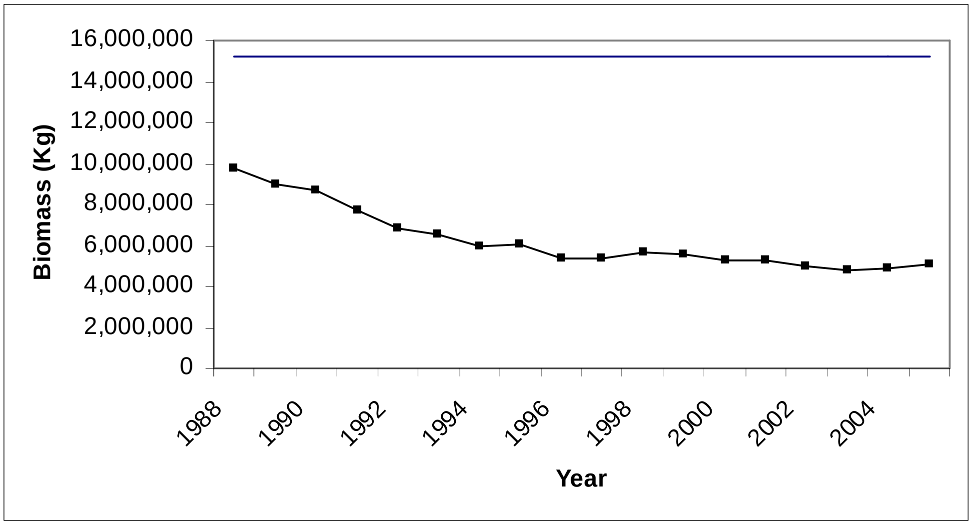

Figure 3. Estimate of stock biomass relative to the unexploited state (top line) shows a steady decline since 1988 following the average CPUE trend.

2.6 Special Comments

The shrimp stocks of Trinidad and Tobago are assumed to be shared with neighbouring Venezuela and hence any assessment of these stocks should ideally be done jointly with Venezuela with management recommendations being applicable to the fisheries of both countries. Joint assessments using shrimp data from both countries have been conducted in the past through the FAO/WECAFC Ad hoc Working Group on the Shrimp and Groundfish Resources of the Guianas-Brazil Continental Shelf. Venezuela should be urged to participate in the CRFM Scientific Meetings or, if this is not possible, to submit the relevant data for analysis.

2.7 Policy Summary

The Government's management objectives and main policy directions as outlined in the marine fisheries policy document (Fisheries Division and FAO 1994) and the goals outlined in the strategic plan (Fisheries Division 2002) are given below. The objectives for management are to:

(1) Implement efficient and cost-effective management;
(2) Ensure through proper conservation and management that fisheries resources are not endangered by overfishing;
(3) Ensure that the exploitation of the fisheries resources and the conduct of related activities are consistent with ecological sustainability;
(4) Maximize economic efficiency of commercial fisheries;
(5) Ensure accountability to the fishing industry and the community at large for fisheries management;
(6) Achieve appropriate cost-sharing arrangements between all the beneficiaries of sound fisheries management.

The current assessments address primarily objective (2). The Government recognizes that a major factor contributing to over-fishing and over-capitalization is the present “Open Access” regime, which allows unregulated fishing effort. The Government in association with the fishing industry will attempt to manage fishing effort on the resources by controlling the number and type of local vessels within a given limit, and by implementing time and area closures, and fishing gear changes. The Government will embark on a licensing programme for all commercial fishing vessels as a means of monitoring the effort applied to the fisheries. Bearing in mind the stability fishing has traditionally provided to rural communities, the Government will give priority to the maximization of employment opportunities through the development of projects for those displaced from the fishery due to effort limitations. The Government will also, through negotiation with neighboring countries, aim to reduce levels of fishing effort on shared fishing grounds. It will also increase its capacity for fisheries surveillance to prevent unauthorized fishing operations in the waters of Trinidad and Tobago. With regard to financial assistance to the fishing industry, the Government intends to phase out many elements of the concessions, rebates and incentives since increased fishing activity is not to be encouraged.

2.8 Scientific Assessments

2.8.1 Description of the Fishery

Shrimp resources in the Orinoco Delta-Gulf of Paria region are exploited by fleets from both Trinidad and Tobago and Venezuela. In the case of Trinidad and Tobago the shrimp is exploited mainly by the trawl fleet, which comprises 102 artisanal, ten (10) semi-industrial and 25 industrial trawlers (2003 Fishing Vessel Census). The artisanal vessels are pirogues 6.7-10.4 m in length with either an inboard diesel engine (Type II) or outboard engines (Type I). These vessels manually deploy one stern trawl. The semi-industrial trawlers (Type III) are 9.3-13.1m in length with 165-174hp inboard diesel engines. These use a single net operated by a hydraulic winch. The industrial vessels (Type IV) use two nets attached to twin outriggers. The nets are set and retrieved using a hydraulic (double-drum) winch. The vessels are 18.7-24.3 m in length and usually have 365 hp inboard diesel engines.

All trawlers operate in the Gulf of Paria on the west coast of Trinidad. The industrial trawlers, and to a much lesser extent the semi-industrial trawlers, also operate west of Saut D'eau on the north coast and in the Columbus Channel on the south coast.

The trawl fleet targets: five shrimp species namely *Farfantepenaeus subtilis, F. notialis, F. brasiliensis, Litopenaeus schmitti*, and *Xiphopenaeus kroyeri*; as well as associated groundfish namely *Micropogonias furneri* and *Cynoscion jamaicensis*. Estimated landings for the entire trawl fleet in 2004 were 712t of shrimp valued at TT$17.8 million and 730t bycatch (groundfish) valued at TT$4.2 million. The artisanal fleets operating in the Gulf of Paria catch *F. notialis, F. subtilis, L. schmitti*, and *X. kroyeri* with *L. schmitti* being particularly dominant in the catches from the northern Gulf. Catches from Venezuela by the artisanal fleet from Trinidad comprise largely *F. subtilis* and *L. schmitti*. *F. notialis* is the dominant species landed by the semi-industrial fleet with smaller amounts of *F. subtilis* and *L. schmitti* also being landed. The industrial fleet lands predominantly *F. subtilis* and *F. notialis*.

The Venezuela trawl fishery comprises two fleets: an industrial fleet and an artisanal fleet. The industrial trawl fleet comprises 88 vessels (mostly metal vessels 24 to 30 m in length). This fleet operates in the southern Gulf of Paria and in front of the Orinoco river delta. The artisanal fleet of trawlers comprises 28 wooden vessels (8 m in length with outboard engines) and operates in the northern area of the Orinoco river delta (Die *et al*. 2004). The Venezuelan industrial fleet lands mainly *F. subtilis* while the artisanal lands mainly *L. schmitti*.

2.8.2 Overall Assessment Objective

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

2.8.3 Data Used

Name	Description
Catch and effort data	Catch and effort data for shrimp by year, month and trawl type / fishing area for 1988-2004, and 1975 for Trinidad and Tobago and Venezuela. In the case of Trinidad and Tobago, catch and effort data were collected by Data Collectors employed at particular landing sites around Trinidad. Data were collected by trip on some days (usually 20 random days) for the month. In the case of the Venezuelan industrial fleet, catches were obtained from logbooks submitted by the captains, and effort was obtained from the Harbour Master Office. In the case of the Venezuelan artisanal fleets, catch and effort data were obtained from the fishers.

2.8.3.1 Total Catches

2.8.3.1.1 Objective

To estimate total shrimp catches (by fleet for Trinidad and Tobago and Venezuela) taken from the stock as input to a dynamic fisheries model used to measure the impact of fishing on the population.

2.8.3.1.2 Method/Models/Data

Trinidad shrimp catches were estimated from a landings sampling programme. Landings and fishing effort sampled each month are first raised to account for non-enumerated fishing days in the month, and then raised to account for vessels based at landing sites not sampled. The numbers of vessels are based on a census of fishing vessels conducted every few years. Prior to mid-2000, sampling of the industrial fleet was very low or non-existent. For these years previous assessments (Die *et al.* 2004) used estimates of Type IV catches based on the Venezuelan industrial fleet catch per day of *F. subtilis*. To improve on these estimates, a time series of active registered industrial trawlers was used as the basis for estimating the total effort for this fleet. The days at sea per vessel per year were estimated from the vessels that were monitored since mid-2000. Catch per day at sea was estimated for those years for which data are available. For other years, a linear correlation between semi-industrial catch per day and the industrial catch per day for the available years was used to estimate the industrial catch per day.

Venezuelan industrial catches were calculated based on the total monthly effort and the monthly CPUE estimated from reported landings by the shrimp trawl fleet. In the case of the Venezuelan artisanal shrimp catches, many years are missing data and hence catches were estimated using annual averages from years for which data are available.

Venezuelan catches were already sorted into species. In the case of Trinidad, sampling provided estimates of species composition, however there are many gaps in the time series.

2.8.3.1.3 Results and Discussion

The working group was unable to split shrimp catches into species compositions with the required degree of reliability. Other sources of uncertainty were too great to claim reliable estimates of catches by species. It was concluded that species specific modeling would require development of a model fitted directly to the species composition sample data to allow for significant sampling errors and missing data.

The species compositions for the Venezuelan fleets were thought to be reliable because landings for the industrial fleet were mainly a single species, *F. subtilis*, which represents 80% of the landings, and for the artisanal only one species is landed (*Litopenaeus schmitti*).

Species compositions are more complex for the Trinidad catch data. There are no reliable ways to fill the gaps outside trying to estimate species composition from a multispecies population. It is evident that species composition does change from year to year, so simply filling in gaps with mean values or applying linear interpolation makes final results very unreliable, particularly considering catches are themselves only estimates. An overall average based on the years for which data are available over the period 1992 to 2002 indicated a species composition of 50% *F. subtilis* and 47% *L. schmitti* for the Trinidad Type I fleet; 41% *L. schmitti*, 24% *Xiphopenaeus kroyeri*, 23% F. notialis, and 11% *F. subtilis* for the Type II fleet; 70% *F. notialis*, 21% *F. subtilis*, and 8% *L. schmitti* for the Type III fleet; and 55% *F. subtilis* and 35% *F. notialis* for the Type IV fleet.

Total catches for all shrimp species estimated for each of the Trinidad and Venezuelan trawl fleets are given in Table 1 while the total shrimp catch for all the fleets combined is illustrated in Figure 4. The catches of the industrial fleet of Venezuela are thought to be reasonably reliable. However, they may be underestimates particularly during the later series due to the observed increase in overboard illegal sale of catch, which is unrecorded. This probably has a bigger impact on the assessment through its effects on the catch rate index rather than on catches and is discussed in more detail there.

The raising of the Venezuelan industrial data to cover unrecorded catches accounts for only 20% of the catch, and therefore compared to other concerns is considered relatively unimportant. Venezuelan artisanal catches are relatively poorly estimated, but form only a small proportion of the total shrimp catch

Venezuela catches and CPUE are missing for the most recent years. To keep the assessment up-to-date, it is important that data are shared for the assessment. This will be achieved most easily if Venezuela is able to send a representative to future CRFM meetings.

Industrial (Type IV) Trinidad vessels have been the most poorly monitored. Only after mid-2000 were catches of about ten out of the 20 or so trawlers recorded giving a reasonable estimate of the total catch for this fleet. Trinidad industrial trawlers take a large proportion of the total catch, therefore poor estimates will add considerably to the uncertainty of the assessment. Trinidad industrial catch estimates derived from the number of registered vessels and the subsequent estimated number of days at sea is given in Table 2. The vessels that have been monitored since mid-2000 suggest an average of 212 days at sea per vessel per year. The catches so derived for 1988 to 2000 were used in subsequent analyses. The alternative shrimp catch time series used in previous assessments (1996-1999) estimated much lower catches for the Trinidad industrial fleet. These estimates were suspected to be biased as catches were lower than current landings but the fleet size is approximately the same. Although we consider the new series more reliable, the alternative series was kept for sensitivity analyses.

It is assumed that there is no discarding of shrimp at sea. In reality, seabob was previously discarded by the industrial Venezuelan fleet. It appears now that it is being landed, although it only forms a small proportion of the catch. Venezuelan catches of *X. kroyeri* for which data are available from 1999 and onward were excluded from this assessment and are not included in Table 1 and Figure 4.

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

Year	Venezuela Artisanal Pedern.[h]	Artisanal NGOP[h]	Industrial	Trinidad Type I	Type II	Type III	Type IV[a]	Type IV[b]
1988	0	0	884993	377678	227444	173462	721435[c]	721435[c]
1989	0	0	1086912	165716	163280	108749	517469	517469
1990	3000	43800	1422945	327427	325666	162088	402687	402687
1991	5000	79100	1433005	255965	362023	161824	395858	395858
1992	31000	61450	1162108	139909	256211	93081	312551[d]	312551[d]
1993	35825	61450	1256850	215969	265738	83454	351656	351656
1994	59553	61450	690755	151076	251945	96579	311540	311540
1995	118490	61450	926547	395135	294034	134591	484241	484241
1996	135363	61450	510071	104853	271230	61952	455520[c]	195266[e]
1997	128580	61450	358114	25717	254398	110863	434727	196588
1998	164028	61450	635828	71055	249544	110215	450853	276905
1999	169300	30025	857677	64913	269982	111229	482885	285531
2000	149997	61450	494068	81241	217988	118475	497954[f]	431053[g]
2001	149536	85293	693000	55372	334497	126310	418730[g]	512726[f]
2002	129880	61450	696000	65584	243121	114674	516625	402635
2003	129880	61450	428820	90655	205720	118298	384590	489071
2004	129880	61450	428820	111195	160991	105187	334471	466841

[a] Preferred Type IV catch series: 1988-2000 based on the number of active/registered vessels and local Trinidad CPUE; and 2001-2004 based on sampled landings raised to account for non-enumerated fishing days each month and non-enumerated vessels based on a vessel census conducted every few years.

[b] Alternative Type IV catch series: 1996-1999 based on Venezuela industrial *F. subtilis* CPUE; 2000 based on sampled landings raised to account for non-enumerated fishing days each month and non-enumerated vessels based on a vessel census conducted every few years; and 2001-2004 based on average CPUE raised by the number of registered vessels.

[c] Estimated based on Type III CPUE.

[d] Estimated from sampled CPUE data, and effort estimate based on the number of registered vessels.

[e] Estimated based on Venezuela *F. subtilis* CPUE and type III effort, used at a previous workshop (Die *et al* 2004).

[f] Estimated based on average CPUE raised by the number of registered vessels.

[g] Estimated based on sampled landings raised to account for non-enumerated fishing days each month and non-enumerated vessels based on a vessel census conducted every few years.

[h] Greyed-cell estimates given as the long term average of the series or previous value.

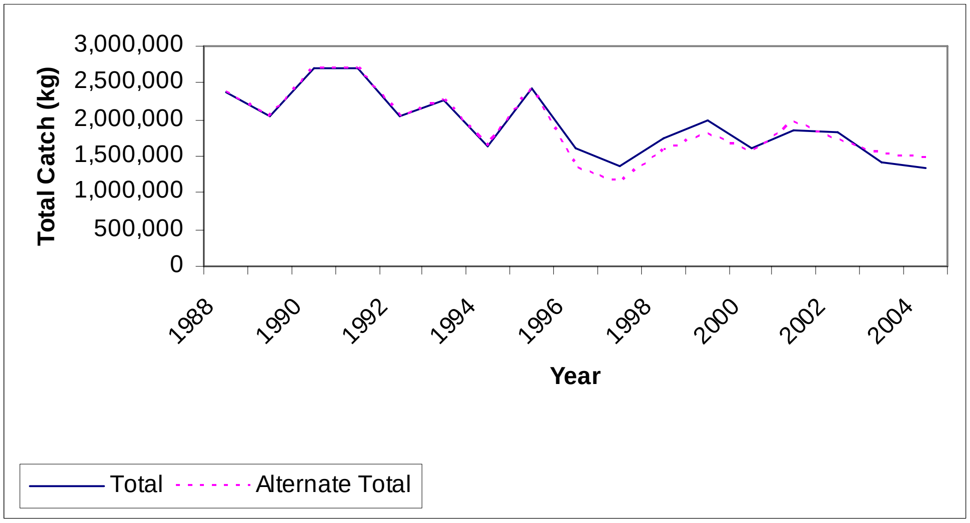

Figure 4. Total shrimp catches derived from summing estimated catches for each gear (Table 1). Type IV Trinidad fleet catches make up quite a significant proportion of the total catch and were thought to be the most poorly estimated, particularly 1996-1999. Two alternate catch scenarios were generated based on the current best estimates and alternative estimates used in previous assessments (Die *et al*, 2004). As can be seen, the alternative catch series is lower from 1996 to 2000, but makes little difference to the final result, as they follow the same general pattern.

Table 2. Trinidad Type IV (industrial) trawlers catch estimates derived from the number of registered vessels and the subsequent estimated number of days at sea. CPUE data were either derived from observations (1992-1995 and 2001-2004) or from correlation with the Type III vessel CPUE (1988-1991 and 1996-2000). The catches so derived for 1988 to 2000 were used in subsequent analyses.

	CPUE (Catch kg per day at sea)	**Number of Registered Vessels**	**Total days at sea per year (# Vessels x 212 days)**	**Catches (kg)**
1988	136.08	25	5302	721435
1989	97.60	25	5302	517469
1990	82.56	23	4878	402687
1991	88.89	21	4453	395858
1992	64.08	23	4878	312551
1993	72.10	23	4878	351656
1994	66.77	22	4666	311540
1995	95.14	24	5090	484241
1996	97.64	22	4666	455520
1997	113.88	18	3817	434727
1998	111.89	19	4029	450853
1999	113.85	20	4241	482885
2000	111.81	21	4453	497954
2001	100.74	24	5090	512726
2002	90.41	21	4453	402635
2003	100.27	23	4878	489071
2004	88.05	25	5302	466841

2.8.4 CPUE Indices

2.8.4.1 Objective

To estimate standardized catch-per-unit-effort for the different fleets to be used as an index of the stock size.

2.8.4.2 Method/Models/Data

The only indices of the stock size available are catch-per-unit-effort for the different fleets. Although biomass surveys (FAO-NORAD Fridtjof Nansen cruises in 1988 (Institute of Marine Research, 1989)) had previously been conducted in Trinidad waters, the surveys had been directed to identify new small scale pelagic resources rather than assess exploited resources.

The Venezuelan industrial fleet has catch and effort data going back to 1971 recorded through log-books. The log-books are checked, filtering out poor records and the final results are thought to be a good indication of landings and days at sea for this fleet. However there are two concerns with using these data:

Not all trawlers may be targeting shrimp. Changes in the proportion of fishing effort targeting shrimp is likely to affect the index and in particular, falling catch rates for shrimp may lead to vessels switching away to finfish, increasing the apparent negative trend in CPUE. This would not affect total catches, but could overestimate the decline in the shrimp resource.

There may be an increasing proportion of the shrimp catch being sold illegally by vessels while at sea. These catches would not be recorded in the official statistics. If this problem has been increasing as suspected, it would increase the apparent rate of decline in CPUE and overestimate the decline in biomass.

An attempt was made to estimate the relative change in catch rate using observer data. It was assumed observers on board would prevent vessels conducting illegal selling at sea, so observer vessels should have a higher catch rate. Unfortunately the number of trips covered by observers is very small, and it was not possible to estimate observer vessel CPUE with the required precision.

Catch and effort are recorded from conducting trip interview sampling of the Trinidad fleets. The data are held in the catch and effort database, which was accessed directly during the meeting.
Nominal catch and effort indices were standardized to remove variation not related to abundance and correct for possible bias due to changing activities of fishers.

The basic model was a Poisson error with a log-link (i.e. a standard log-linear model). The model's linear terms were multiplicative, because of the log-link function. Indices and covariate terms were applied to correct CPUE. The model was fitted using Solver in an MS Excel spreadsheet. The model can be written as:

$$C_i = \exp\left(Ln\left(f_i\right) + M_i + V_i + A_i\right)$$

where for each trip i, C_i = expected catch, f_i = days at sea, V_i the appropriate term based on the fleet.year, M_i the term for the month and A_i the appropriate term for the fishing area. The fleet.year terms (V_i) are used to generate the standardized indices.

The standardization was carried out using a basic generalized linear model approach. Only the main factor terms were used for month (removing seasonal effects) and fishing area for Trinidad only. All vessels were trawlers and data series were split into the six main fleets: industrial and artisanal for Venezuela and vessel types I to IV for Trinidad. This resulted in separate models for the Venezuelan industrial and artisanal fleets as the data were already accumulated into months and raised. However, the fleet.year interaction terms could be generated for Trinidad as the raw trip data were extracted from the catch and effort database. The year parameter estimates from the Venezuelan series and fleet.year parameter estimates from the Trinidad series were used to generate the standardized indices. Using the fleet.year interaction terms allowed a more parsimonious model as the fishing area and month parameters only needed to be estimated once for all Trinidad fleets.

2.8.4.3 Results and Discussion

Standardization made little difference to the general patterns in the data (Figures 2 and 3; Table 3). Where data are available, the CPUE indices show a decline since 1975. The only conflicting trend is the increasing Type I CPUE towards the end of the series. Type I CPUE was the most affected by the standardization, suggesting catch rates for these vessels depend to a large extent on the season and area they fish. Therefore, the increasing trend is probably due to changing activity rather than changes in stock size. Understanding the upward trend to ensure proper interpretation will be important. Further analyses of these data, perhaps standardizing this fleet separately from the others, should confirm whether this can or cannot be interpreted as increasing stock size.

The highest Trinidad catch rates occur in February (Figure 4) coinciding with the period of full recruitment. Venezuela waters have the highest CPUE (Figure 5) probably because they are closer to the river estuaries, the areas of highest productivity.

The potential models were not fully explored due to a lack of time and covariate information. Care needs to be taken in carrying out standardization in order to avoid introducing bias; therefore it was felt preferable to apply only minimal changes in this case. Not all possible covariates were available for this analysis. Some improvement in the indices should be possible if additional covariates relating to fishing power of vessels can be assembled.

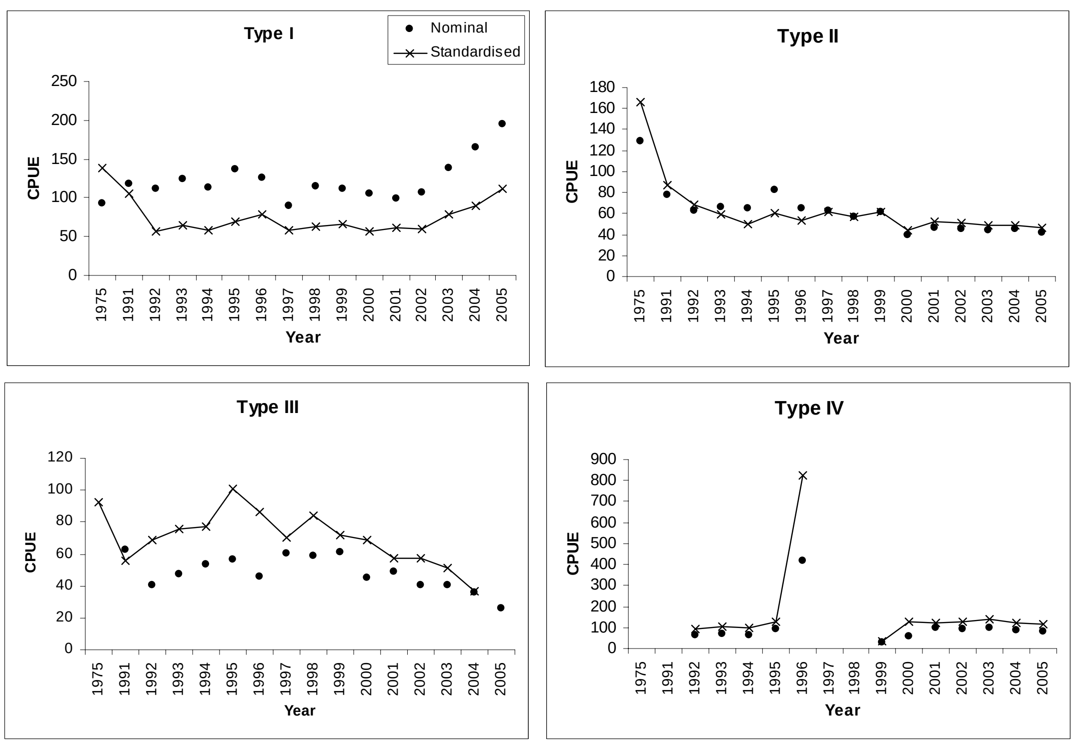

Figure 2. Standardized (–) and nominal (●) CPUE indices for Type I (top left), Type II (top right), Type III (bottom left) and Type IV (bottom right) Trinidad fleet time series. There is a gap in the graphed series between 1975 and 1991.

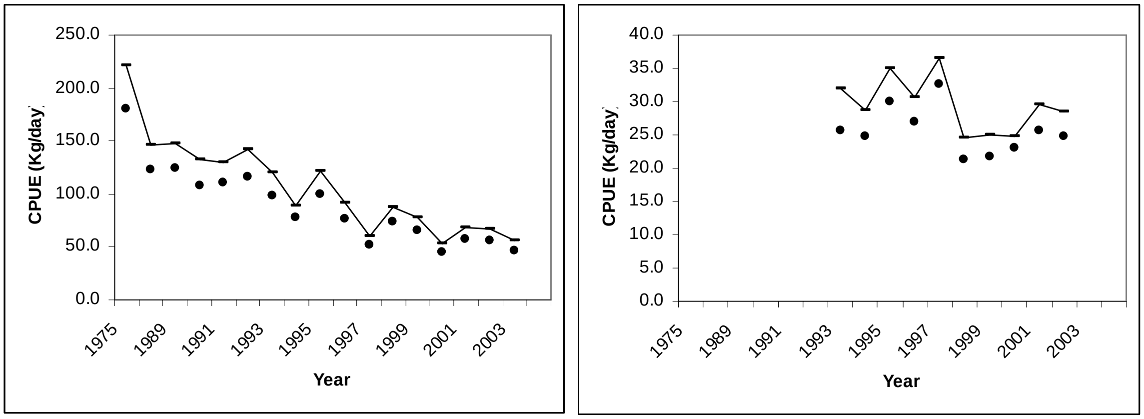

Figure 3. Standardized (–) and nominal (●) CPUE indices for the Venezuelan industrial (left) and artisanal (right) fleets. Standardization made little difference to either trend.

Table 3 Standardized CPUE indices (kg per day at sea) obtained from log-linear model year terms. Hence, the values are the average January catch rates, and for the Trinidad fleets, on the "North Coast".

	Trinidad				Venezuela	
	Type I	Type II	Type III	Type IV	Industrial	Artisanal
1975	138.0	166.3			221.0	
1988					146.8	
1989					147.6	
1990					132.2	
1991	104.9	86.8	92.3		129.9	
1992	57.3	69.0	56.1	95.1	142.4	
1993	65.0	58.7	69.0	105.5	119.9	32.0
1994	57.9	50.1	75.9	101.0	88.5	28.7
1995	69.1	60.5	77.2	125.0	121.3	34.9
1996	78.1	53.3	101.2	827.1	92.0	30.7
1997	58.8	61.8	86.4		60.1	36.6
1998	62.8	56.7	70.3		86.9	24.7
1999	66.3	61.1	84.3	34.3	78.0	24.9
2000	56.9	44.5	71.6	128.3	53.7	24.7
2001	61.1	52.5	68.8	119.2	68.7	29.6
2002	59.9	51.3	57.2	129.1	67.6	28.4
2003	79.0	48.5	57.2	140.8	55.6	
2004	88.8	49.2	51.1	123.4		
2005	111.5	46.5	36.9	114.4		

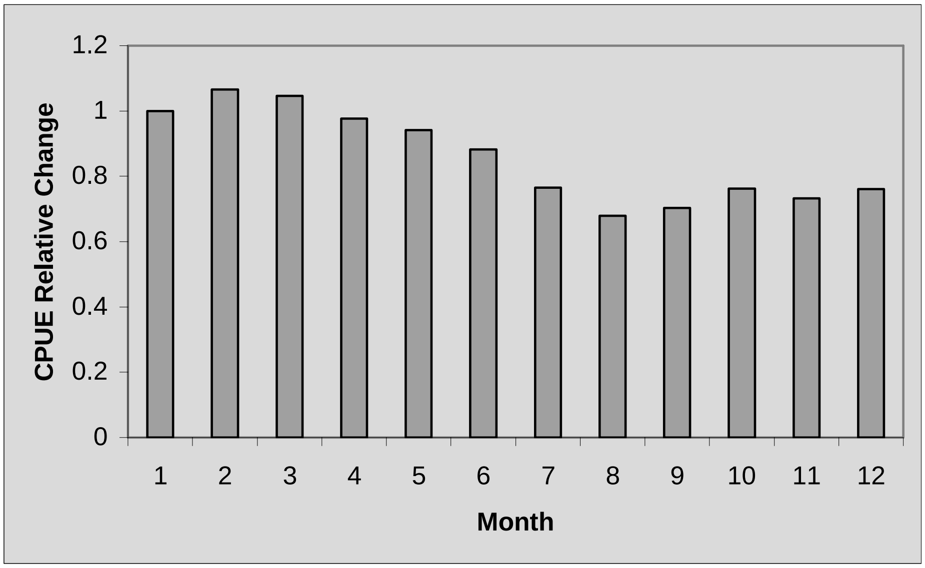

Figure 4. Parameter estimates for Trinidad catch rates within the year. Recruitment probably occurs in December/January, so higher catch rates then are driven by new recruits.

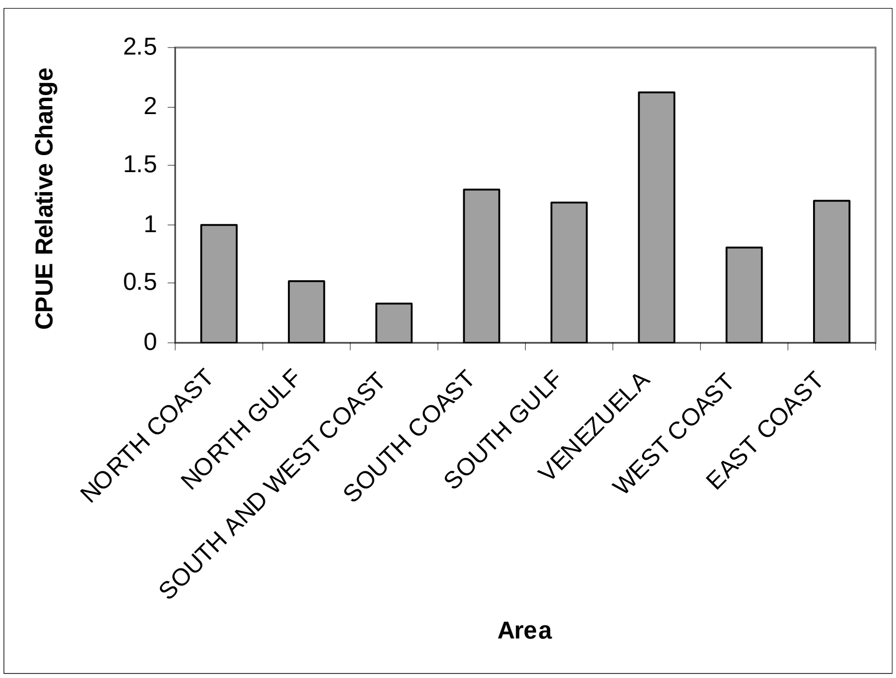

Figure 5. Trinidad relative change in catch rates between fishing areas in Trinidad.

2.8.5 Population Model

2.8.5.1 Objective

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

2.8.5.2 Method/Models/Data

Because the working group felt unable to estimate Trinidad species catches accurately, the model was limited to a surplus production model for overall shrimp biomass. This model simply describes biomass depletion and growth, without differentiating by species or size. It contains the minimum biological information, but can be a useful empirical description of productivity for providing management advice.

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

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

$$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{B_\infty}\right) - C_t \qquad (15)$$

$$Y_{gt} = q_g B_t$$

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

The state of the stock is defined as the biomass (B_t) divided by the unexploited biomass (B_∞). If the stock state falls below that required for the maximum sustainable yield (0.5), the stock can be classified as biologically overfished.

The MSY fishery reference point requires some information on abundance index values when the stock is unexploited. Although Venezuelan catches exist to 1973, Trinidad catches could only be estimated to 1988, well after the fishery began. Therefore additional information was required to infer the state of the stock in 1988.

Both Trinidad and Venezuela possess historical catch and effort data for 1975, making this a useful base year. The aim is to estimate the CPUE for this year as a proportion of the expected unexploited CPUE.

By 1975 the fishery had begun, but was not well developed. A fleet of small trawlers began operation in Trinidad in 1953. In addition, in 1969 there was a fleet of Gulf of Mexico-type industrial trawlers (Kuruvilla *et al*. 2000). In Venezuela, the industrial fishery started around 1968. The earliest available article describes the fishery in 1955 as having 5 vessels catching 400 t of shrimp a year in Trinidad waters. Ewald *et al.* (1971) describes a fledging Venezuelan fleet of medium sized (10-12m) and smaller (8m) trawlers in 1968/1969 with total landings of shrimp reported to be 76t in 1969 and 82t in 1970. It was also reported that a fleet of Trinidadian small (8m) trawlers landed 485t in 1969.

The stock was therefore relatively lightly fished in 1975, with an approximate total catch around 600t. Assuming the 600t catch was close to the equilibrium catch in 1975 (C_{1975}) we can estimate the approximate stock state given the population parameters from equation 1 (r, B_∞):

$$-rU_t^2 + rU_t - C_{1975}/B_\infty = 0$$

$$U_t = \frac{1 + \sqrt{1 - C_{1975}/C_{MSY}}}{2} \quad C_{1975} < C_{MSY} \qquad (2)$$

where $U_t = B_t/B_\infty$ the state of the stock varying from 0 (extinct) to 1.0 (unexploited) and $C_{MSY} = rB_\infty/4$ the catch at maximum sustainable yield. Each expected 1975 CPUE index point can be defined as:

$$Y_{g,1975} = q_g B_\infty U_t$$

where $Y_{g,1975}$ = the expected CPUE in 1975, q_g = the catchability paremeter and B_∞ = unexploited stock size as in equation (1).

This is useful for defining the unexploited state as a reference point, as it essentially defines the approximate index value when the stock is only lightly fished (i.e. $q_g B_\infty$).

Both Venezuela and Trinidad have CPUE data points for 1975, which can be used to fit the model using equation (2) even though catches between 1975 and 1988 are not known. Venezuela has a complete CPUE series to 1975, but Trinidad is in the process of entering historical data from as far back as the 1950s into a database and aim to complete the series to the present.

The model was fitted to the available standardized CPUE indices (Table 3). In general, it was assumed that all indices should be used if possible. A weight is also required representing the relative reliability of the index. The preferred method was to weight each series equally as there was no a priori reason to discriminate between them.

A normal log-likelihood (least squares) was used to fit the model. There was no evidence for variance change in the series and as the estimated means for the indices were being used, the normal probability distribution was considered a reasonable assumption for the likelihood.

$$LL = \sum_g w_g \sum_t \left(Y_{gt} - q_g B_t\right)^2$$

where w_g = series weight for fleet g (assumed 1.0 in this analysis), Y_{gt}= observed CPUE in year t for fleet g, q_g = catchability for fleet g and B_t = the stock biomass at time t from the population model. Using least squares allows the maximum likelihood index q's to be estimated directly through regression, which makes fitting more reliable, particularly for the bootstrap simulations.

$$q_g = \frac{\sum_t Y_{gt} B_t}{\sum_t B_t^2}$$

The squared difference between the model-estimated CPUE and observed CPUE is otherwise minimised with respect to the population model parameters using the MS Excel Solver.

Approximate confidence intervals were generated by the 'bootstrap' method. Data were simulated using the observed and expected values to generate data which, assuming the model is correct, we could equally well have obtained in reality. The random simulated data are then fitted in the same way to generate simulated parameter estimates. The collection of parameter estimates are treated as though they are drawn from a probability distribution of the parameters representing the uncertainty associated with their estimation.

In this case, we used a simple residual-based method, where all available residuals from all series are assumed to be drawn from the same normal distribution with 0 mean. Residuals are then drawn at random with replacement and added to the best-fit expected CPUE for the year and fleet to generate a new data point. These new data were then used to fit the model and obtain a "bootstrap" estimate. This was done 1000 times to generate a frequency of estimates which was used to get the median and confidence intervals based on the 10, 50 and 90-percentiles. While bootstraps are simple, they suffer some statistical problems and can be inaccurate for small samples. Combining residuals from all series attempted to minimize this by allowing random draws from a larger set. The residuals from each series did not have very different variances.

2.8.5.3 Results

The Trinidad Type IV (industrial) fleet index was not used as it was considered unreliable before 2000. Sampling of this fleet prior to 2000 was poor or non-existent. The reliable part of the series 2000-2004 has no trend, which is the same as the other indices, therefore only using this period does not make any difference to the analysis.

The equal weighting for series (excluding the Trinidad Type IV fleet) produced a reasonable fit for the model and relatively stable results. The general results indicate the state of the stock is well below maximum sustainable yield (MSY) and the current fishing mortality is causing the stock to continue to decline. The biomass appears to have consistently declined since 1988 (Figure 6). The maximum sustainable yield is in the region of 1700 t and catches higher than this will not be sustainable. Rebuilding the stock could realize 35-80 % increase in the current catch rate, while making the same catch as currently being landed.

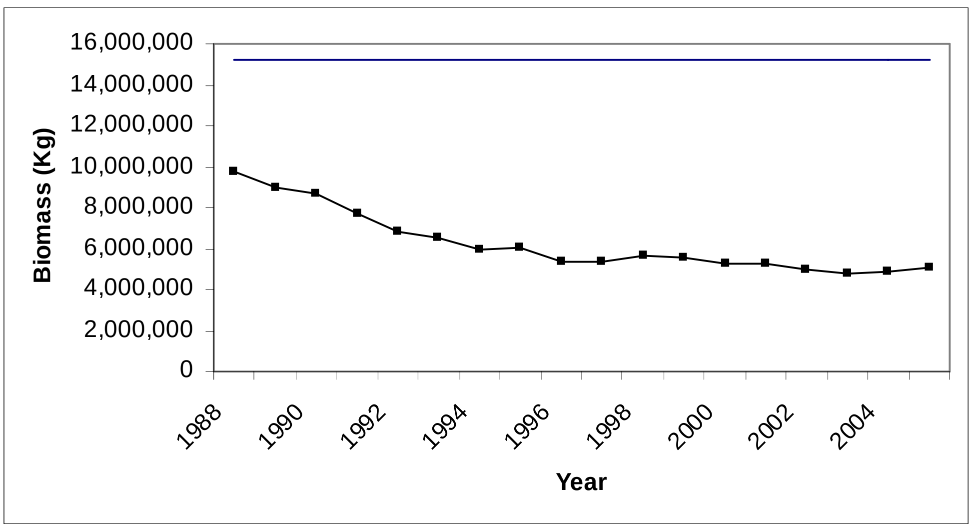

Figure 6. Estimate of stock biomass relative to the unexploited state (top line) shows a steady decline since 1988 following the average CPUE trend.

Table 4. Results from the stock assessment model fit where the series (excluding the Trinidad Type IV fleet) are all equally weighted. The parameter estimates are given at the top of the table (B_{1988} - q Ven. Artisanal), and the more general results at the bottom. "Replacement F" is the fishing mortality which will cause no change in the population. "Target Increase Catch Rate" is the catch rate expected at MSY relative to the current catch rate. The main result is that the stock state is below the maximum sustainable yield and looks to be in continuous decline.

				Percentiles		
	Maximum Likelihood	Average	Standard Deviation	0.05	Median	0.95
B_{1988} (kg)	9,729,780	10,536,851	3,340,546	7,156,448	9,853,854	15,583,944
r	0.470	0.470	0.145	0.237	0.470	0.714
B_{∞} (kg)	15,183,182	16,706,205	6,566,904	10,616,912	15,210,887	26,754,712
q TT Type I	1.17E-05	1.18E-05	3.29E-06	6.77E-06	1.17E-05	1.75E-05
q TT Type II	1.06E-05	1.06E-05	3.02E-06	5.88E-06	1.05E-05	1.56E-05
q TT Type III	1.23E-05	1.23E-05	3.6E-06	6.77E-06	1.21E-05	1.83E-05
q Ven. Industrial	1.57E-05	1.57E-05	4.22E-06	8.99E-06	1.56E-05	2.26E-05
q Ven. Artisanal	5.06E-06	5.13E-06	1.67E-06	2.63E-06	5.01E-06	8.08E-06
MSY (kg)	1,782,683	1,765,822	116,071.8	1,582,775	1,782,336	1,905,262
F_{MSY}	0.235	0.235	0.072	0.119	0.235	0.357
Current F	0.298	0.300	0.087	0.169	0.297	0.450
Replacement F	0.319	0.319	0.100	0.166	0.318	0.487
1975 State	0.907	0.906	0.010	0.894	0.907	0.914
1988 State	0.641	0.642	0.057	0.562	0.639	0.737
Current State	0.322	0.320	0.028	0.277	0.321	0.368
Target Increase Catch Rate	1.555	1.573	0.137	1.359	1.559	1.804

2.8.5.4 Discussion

The upward trend in the Trinidad Type I CPUE has counteracted the general downward trend in the other series. If, as suspected, this is not an indication of increasing biomass, the flattened downward trend in the biomass estimate (Figure 6) is probably over-optimistic.

The analysis presented represents a good standard assessment. While better models should be continued to be developed, this assessment is adequate to provide precautionary management actions. As such, the assessment should be updated, while improvements should be made in the efficiency and accuracy in assembling the available data. Many of the tasks for Trinidad can be automated for the catch-effort database, ensuring consistency in updating the assessment as new data become available. The Venezuela data would be improved by going back to original data sources, which should allow a better standardization method to be applied.

2.8.5.5 Conclusion and Recommendations

The stock is overfished relative to the maximum sustainable yield.
The stock biomass is stable or declining. Current catches probably cannot be maintained in the long term.

There could be considerable benefit from rebuilding the stock, with significant increases in catch rates while obtaining the same level of landings as currently observed. The disadvantage is there will be an initial loss to the fishery during the rebuilding process (Figure 1).

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

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

2.9 References

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3. The Red Snapper (*Lutjanus purpureus*) fishery of Guyana

Rapporteurs: Pamila Ramotar, Fisheries Department, Guyana, and Clay Porch, SEFSC, NMFS, Miami, Florida.

3.1 Management Objectives

According to the Draft Marine Fishery Management Plan for Guyana (Revised February 2006), the management objectives for this Fishery are to:

- 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.

3.2 Status of Stocks

The preliminary results from the present analysis indicate that the stock may be overfished.

3.3 Management Advice

Given the possibility that the stock may be overfished current levels should be reduced. However, the precise optimal levels of effort have not been reliably determined. Further extensions of the model are required to set proper reference points. It may be possible to improve the exploitation pattern as well as alter the overall effort. This technical solution to improving yields may include changes in mesh size and gear types, if these management measures are considered acceptable.

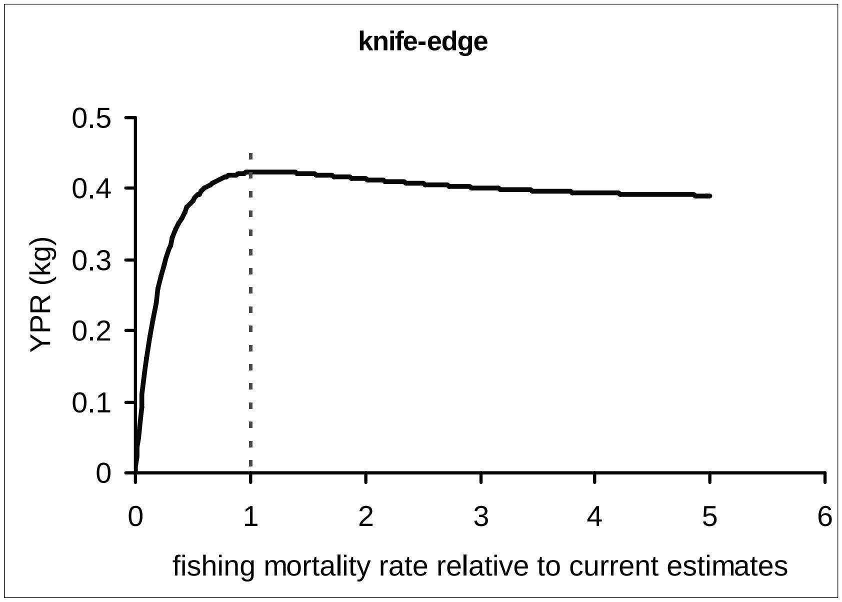
3.4 Statistics and Research Recommendations

- On-going collection of a minimum, accurate and adequate catches, effort, size frequency and age data
- There is a clear needed to collect catch and effort data for all months and areas where fishing is occurring and to take this information into account when developing CPUE series.
- Produce regular national updates of assessments to determine the status of stocks and desirable management measures such as suitable effort
- Collection of data for each month etc including data for Pots and Traps and Trawls.
- Collaborate with countries such as Suriname, Venezuela and Brazil for stock assessments.
- Raise and compute length frequencies at various areas.

3.5 Stock Assessment Summary

Catch per unit effort (CPUE) series were generated for the hook and line fishery from 1995-2005 for all months combined and for July and August in particular (summer period). Available landings and CPUE statistics represented only a fraction of the total fishery. Instead, the fishing mortality was estimated from the length frequency data alone using a modification of the mean-size method of Gedamke and Hoenig (1995) by C. E. Porch (unpublished Excel spreadsheet). This model is similar to that published by Beverton and Holt (1958), but allows the fishing mortality rate to vary through time and fits a series of annual mean-size observations. The preliminary results from the present analysis indicate that the stock may be overfished.

The assessment appears to indicate that overfishing is occurring in the sense that the fishing mortality rate is probably greater than the natural mortality rate. From a maximum yield per recruit perspective the fishery appears to be operating near optimally under either assumed selection pattern (see Figure A); however, continued fishing at this level implies a belief that future recruitment will continue at current levels.



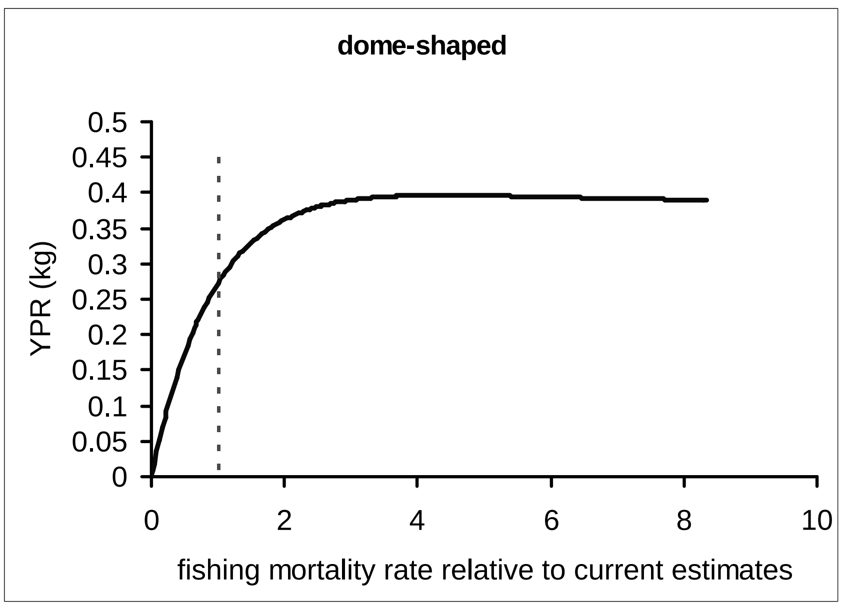


Figure A. Yield-per-recruit estimated assuming the knife-edge and dome-shaped selection patterns. The horizontal axis may be interpreted as effort levels relative to the current levels estimated under the corresponding assumed selection patterns.

3.6 Special Comments

All catches need to be assembled for this multispecies, multigear fishery. Total catch data by gear are required because of this only one gear was analysed. Data from other countries such as Suriname and Venezuela are needed so that a comparison analysis can be done among the countries as the resource is shared.

3.7 Policy Summary

The policy summary is 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.

3.8 Scientific Assessments

3.8.1 Background

The red snapper fishery of Guyana consists of a semi-industrial fleet. Fishing occurs mainly on the continental slope.

In 1995 there was a decline in the local red snapper fishery; the highest number of boats was about eleven (11), but that dropped to seven (7) in 1997. The decline was because some operators had reverted to using the gillnet polyethylene (drift seine) as they did not have as efficient technology for catching snapper as their counterparts in Trinidad & Tobago and Venezuela.

Since then there has been an expansion of the fleet over the years. Guyana now has a licensed fleet of Seventy-five (75) vessels; twenty (20) are Venezuelan owned and leased to Royal Caribbean Inc. and fifty-five represent the local fleet. There are fifty-five Guyanese vessels use pots and traps, the remaining forty vessels use hooks and line. The average fishing trip is 18 – 24 days at sea.

Management units for the snapper/grouper fishery should be considered at two levels. The first relates to the distribution of juveniles over the continental shelf and to the slope/edges and the other to the shared nature of the stocks on the Guianas-Brazil shelf, with the data (FAO/NORAD Survey 1988) suggesting overlap of the lutjanid stocks with Suriname to the south and possibly with Venezuela to the north.

3.8.2 Objectives

Determine the status of the red snapper fishery and identify target and limit reference points for fishing effort.

3.8.3 Data Used

Name	Description
Catch and effort	Log sheets submission with catches per day for hand line vessels for 1996 to 2004. Catch and effort data taken from the ongoing landings sampling programme for the Offshore Industrial and Inshore Artisanal Fisheries for the pot and trap vessels from 1998 to October 2004.
Length frequency data	Length frequency data taken from the ongoing landings sampling programme for the offshore industrial and inshore artisanal fisheries for the pot and trap vessels from 1998 to October 2004.

3.8.4 Assessment 1

3.8.4.1 Objective

Estimate fishing mortality and selectivity suitable for a simple yield-per-recruit assessment.

3.8.4.2 Method/Models

Catch and effort information was available for several gear types. However in most cases the data covered only a few months in a few years. The only complete data set came from the hook and line fishery between 1995 and 2005 (these vessels are required to report all of their landings to Guyana authorities). While the hook and line fishery is generally regarded as the most important, the limited data that were available for fish pots indicated that the landings from this gear were substantial (in some cases nearly as large as the landings from hook and line). Moreover, the number killed as a bycatch of shrimp trawling has not been adequately quantified. Thus, the landings statistics that are available underestimate the total landings from Guyana by as much as 50%. The fact that landings statistics were available only for Guyana becomes even more problematic when it is considered that the snapper resources in the waters of neighbouring countries probably constitute a single stock.

Catch per unit effort (CPUE) series were generated for the hook and line fishery from 1995-2005 for all months combined and for July and August in particular (summer period). The trends in these two indices are very different (Figure 2). The reason for this is that the fishery operated in different months in different years (the months of July or August being the only months consistently fished) and catch rates appeared to vary by month. Thus, the annual CPUE trend may reflect variations in the distribution of fishing effort among months more than it does an actual trend in abundance. The summer CPUE trend might be regarded as a better measure of the relative abundance of red snapper, however an analysis of the length frequency data indicated that the areas fished also changed from year to year (Figure 3). The large year-to-year changes in the summer CPUE are consistent with this observation and also with the activities of a developing fishery. In the present case, neither series in Figure 2 was regarded as a reliable indicator of abundance and therefore could not be used for an assessment. In any case, there is a clear need to collect catch and effort data for all months and areas where fishing is occurring and to take this information into account when developing CPUE series.

The catch-at-length method applied previously was not used this year because the above investigations revealed that available landings and CPUE statistics represented only a fraction of the total fishery. Instead, fishing mortality was estimated from the length frequency data alone using a modification of the mean-size method of Gedamke and Hoenig (1995) by C. E. Porch (unpublished Excel spreadsheet). This model is similar to that published by Beverton and Holt (1958), but allows the fishing mortality rate to vary through time and fits a series of annual mean-size observations. The main underlying assumptions are that growth follows a known von Bertalanffy relationship, selectivity-at-age is known (or constant beyond a certain age) and that recruitment has been relatively constant.

The natural mortality rate of red snapper is unknown. The value used was 0.25 yr^{-1} (all ages) (used in a previous assessment). The growth of red snapper in the region has not been studied, therefore we used a von Bertalanffy relationship published for red snapper caught in Trinidad (Manickchand-Heilman and Phillip 1996). This relationship is expressed in terms of total length, whereas the actual measurements are in fork length. Therefore we converted the growth curve from total length to fork length by use of a divisor *c* gleaned from Fish Base. Length was converted to weight for the yield per recruit analysis. These parameters are summarized in Table 1.

The maximum observed age indicated on FISHBASE was 18 yrs. The mean-size calculations included up to age 20 as the FISHBASE values came from an exploited population. The selectivity on each age group was not known. The selection vector estimated during the previous assessment was dome-shaped with maximum selection for ages 3 to 5. However, as mentioned previously, these estimates were predicated on spurious CPUE and landings data and are therefore unreliable. Inspection of the length frequency distributions reveals that the peaks were generally between 30 and 36 cm, which roughly correspond to the size, expected for age 3 animals. Therefore the mean-size approach was applied with two alternative selection vectors, the dome-shaped relationship from the previous assessment and a knife-edge relationship starting at age 3 (Table 2). Use of the mean-size approach also requires the mean to be computed from the observed length-frequency data pertaining to age classes greater than or equal to the first age in the analysis (here age 3). This requires truncating the length-frequency data at the minimum size associated with age 3, which in this case is uncertain. The growth curve indicates that the expected length at age 3.0 is 31 cm; however, owing to variations in length at age it is probable that some age 2 animals exceed 31 cm and some age 3 animals are less than 31 cm. An appropriate truncation point would be where the overlap between the two age classes balances out, but this is difficult to determine owing to the lack of information on age. Hence, runs were made using alternative truncation points at 31 cm and 33 cm.

Mean sizes were calculated from length frequency data collected between 1995 and 2004 from commercial hook and line gear. Relatively few data were available for the other important gear types (traps, trawl and gillnets). Data also were collected in 2005, but were not used in the present analysis because only a few months were represented.

3.8.4.3 Results

Table 1 Parameters for Von Bertalanffy growth model, length weight conversion and natural mortality and selection used in the assessment to compute mean size at age and in the yield-per-recruit model.

Von Bertalanffy growth equation (TL)		
K ($year^{-1}$)	L_∞ (cm)	T_0
0.13	85.1	-0.86
Length-Weight Conversion		**FL-TL conversion**
A	B	C
0.0141	2.99	1.076
Natural mortality rate (M)		
0.25		
Selection by age from previous assessment (begin age 3)		
1.0, 0.9, 0.6, 0.3, 0.2, … , 0.2		
Maximum age in calculations		
20		

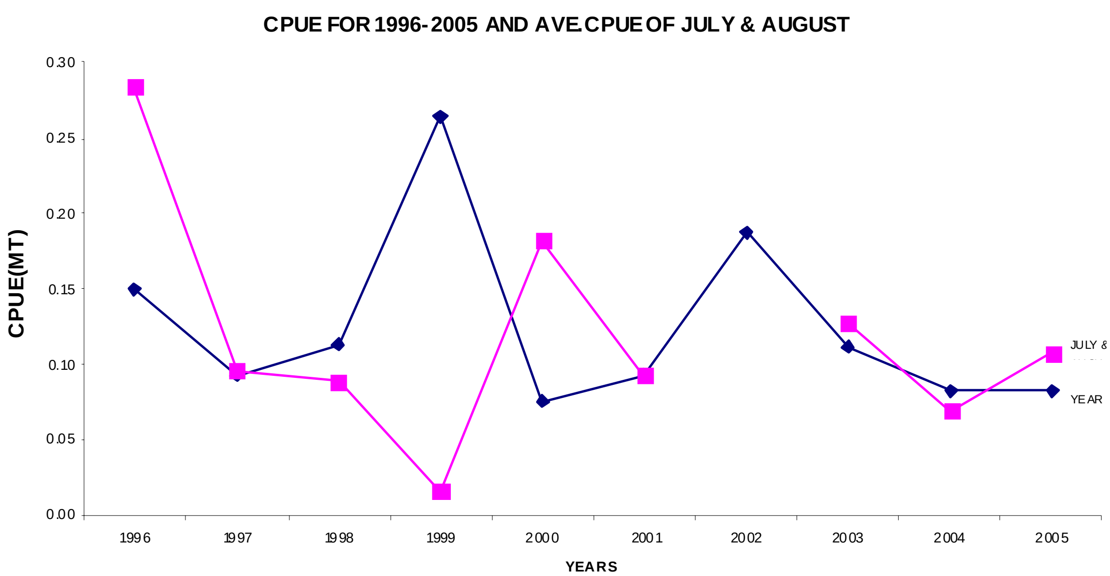


Figure 1. Catch per unit effort in metric tonnes for Hook and Line.

Figure 2 (a)

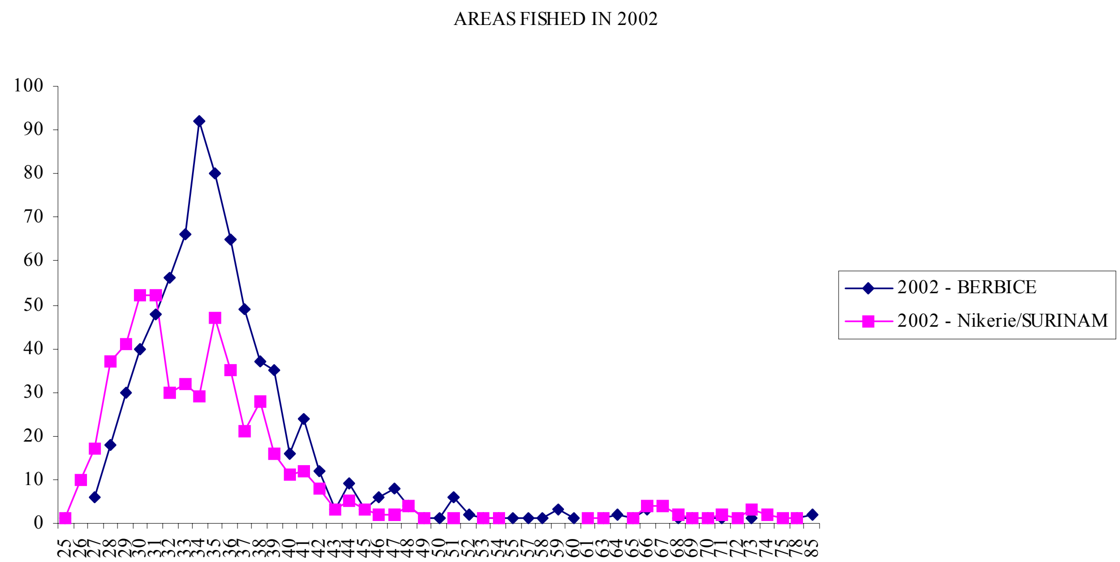


Figure 2 (b)

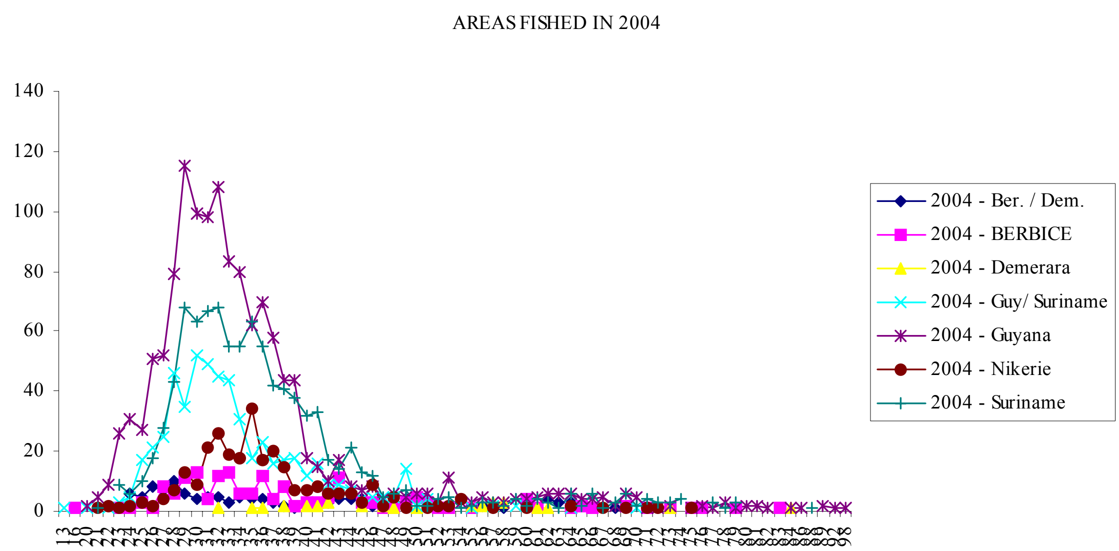


Figure 2. Showing the areas fished in 2001, 2002 and 2004.

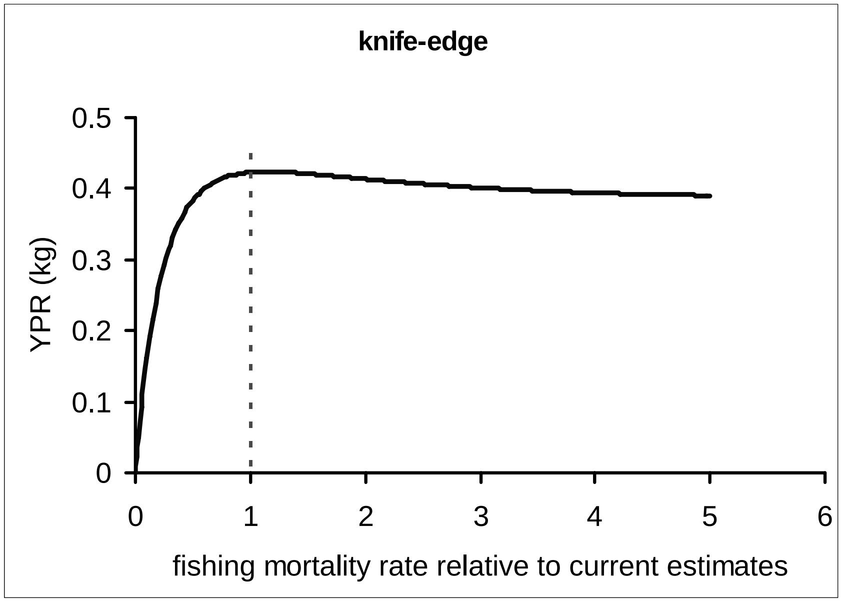
The average lengths computed from the hook and line length frequency distributions truncated at 31 cm and 33 cm are shown for each year in Table 2. The estimates of fishing mortality for the knife-edge and dome-shaped selection patterns are summarized in Table 3. The results from yield per recruit analyses using the dome-shaped and knife-edge selection patterns are summarized in Figure 3.

Table 2. Mean, variance and number of observations for length frequency distributions from the hook and line fishery for red snapper using only lengths above 31 cm or 33 cm.

	33 cm cutoff			**31 cm cutoff**		
Year	**mean**	**variance**	**number**	**mean**	**variance**	**Number**
1995	**45.1**	**2086.1**	**130**	**42.9**	**1903.1**	**155**
1996	**42.7**	**1848.6**	**1716**	**41.2**	**1724.7**	**1998**
1997	**42.5**	**1805.8**	**522**	**41.1**	**1699.4**	**597**
1998	**39.8**	**1604.7**	**457**	**37.3**	**1406.7**	**662**
1999	**37.1**	**1371.3**	**205**	**35.2**	**1231.7**	**309**
2000	**46.2**	**2224.0**	**111**	**41.8**	**1849.7**	**157**
2001	**43.4**	**1966.8**	**271**	**41.6**	**1811.3**	**321**
2002	**39.1**	**1559.0**	**732**	**37.0**	**1391.8**	**1016**
2003	**42.1**	**1809.5**	**289**	**38.6**	**1527.2**	**430**
2004	**42.3**	**1863.9**	**1721**	**39.1**	**1595.4**	**2447**

Table 3. Estimates of fishing mortality rate by year for the knife-edge and dome-shaped selection curves obtained by fitting to mean size data truncated at 33 and 31 cm.

	33 cm cutoff				**31 cm cutoff**			
	knife-edge		**Dome**		**knife-edge**		**Dome**	
Year	**constant**	**variable**	**constant**	**variable**	**constant**	**Variable**	**constant**	**Variable**
1995	**0.21**	**0.14**	**0.01**	**0.01**	**0.40**	**0.21**	**0.24**	**0.08**
1996	**0.21**	**0.60**	**0.01**	**0.18**	**0.40**	**0.88**	**0.24**	**1.80**
1997	**0.21**	**0.60**	**0.01**	**0.18**	**0.40**	**0.88**	**0.24**	**1.80**
1998	**0.21**	**0.60**	**0.01**	**0.18**	**0.40**	**0.88**	**0.24**	**1.80**
1999	**0.21**	**0.13**	**0.01**	**0.01**	**0.40**	**0.41**	**0.24**	**0.14**
2000	**0.21**	**0.13**	**0.01**	**0.01**	**0.40**	**0.41**	**0.24**	**0.14**
2001	**0.21**	**0.13**	**0.01**	**0.01**	**0.40**	**0.41**	**0.24**	**0.14**
2002	**0.21**	**0.13**	**0.01**	**0.01**	**0.40**	**0.41**	**0.24**	**0.14**
2003	**0.21**	**0.13**	**0.01**	**0.01**	**0.40**	**0.41**	**0.24**	**0.14**
2004	**0.21**	**0.13**	**0.01**	**0.01**	**0.40**	**0.41**	**0.24**	**0.14**



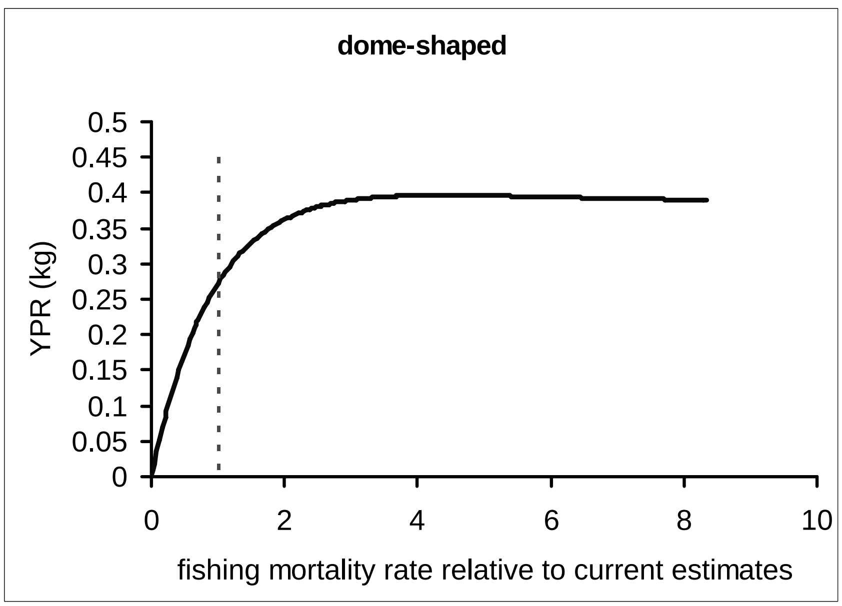


Figure 3. Yield-per-recruit estimated assuming the knife-edge and dome-shaped selection patterns. The horizontal axis may be interpreted as effort levels relative to the current levels estimated under the corresponding assumed selection patterns.

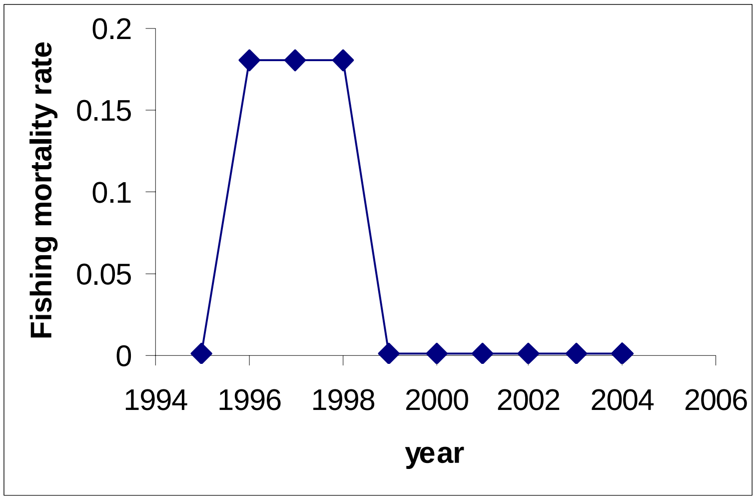


Figure 4. Showing fishing mortality from 1995-2005

3.8.4.4 Discussion

Overall, the assessment appears to indicate that overfishing is occurring in the sense that the fishing mortality rate is probably greater than the natural mortality rate. From a maximum yield per recruit perspective the fishery appears to be operating near optimum under either assumed selection pattern; however continued fishing at this level implies a belief that future recruitment will continue at current levels. If recruitment is in fact dependent on spawning biomass, then the current level of fishing may lead to recruitment overfishing.

When time trends are estimated, the mean size model suggests that fishing mortality was generally low prior to 1995, increased rapidly to very high levels during the late 1990s, and then decreased again to low levels after 2000 (Figure 4). The estimates of low fishing mortality followed by a rapid increase are consistent with reports that only a few vessels targeted red snapper prior to the early 1990s, as compared to 39 in 1995 and 70 currently. The decrease in fishing mortality estimated to occur after 2000, however, is inconsistent with the relatively higher level of effort exerted during that period. This inconsistency lead to the suspicion that the changes in mean size observed after 2000 may actually reflect a change in fishing areas. Detailed information on fishing area was available during this meeting for 2001, 2002 and 2004. Examination of the length frequencies for each area revealed that fish caught in Berbice, Nikerie, and Suriname was larger than those from the other areas. In the case of 2004, many areas were represented, but in the case of 2001 and 2002, the primary fishing areas were those with larger fish. Hence, we suspect that the increase in mean size estimates after 2000 are an artifact of increasing fishing in areas with larger fish rather than a decrease in overall fishing mortality. It will therefore be useful to go back to the raw data and develop length frequency distributions for each area with a sufficient number of samples. An analysis of the time trends in mean size from these area-specific distributions may provide a better picture of the time trends in fishing mortality.

The total catches for the red snapper fishery were not accounted for. The data available for the assessment was mostly for hook and line. There appears to have been substantial catches by fish pots as well, but landings estimates were available for only a few months in a few years. Moreover, substantial catches may be coming from other regions of the shelf outside of Guyana, which are likely to represent the same stock. It would be valuable to expand the data and develop a model that uses the total landings from all gears in all countries. It would also be useful to develop and implement a survey that would collect data appropriate for an ageing study. Such a study would allow the selectivity pattern to be estimated; the selectivity being a major uncertainty in the present analysis.

3.8.4.5 Management

The assessment implies that effort should be reduced. The precise optimal level of effort is not reliably known. Further extension of the model to include all catches is required to set proper reference points. It may be possible to improve the exploitation pattern as well as alter the overall effort. This technical solution to improving yields may include changes in mesh size and gear types.

3.8.4.6 Recommendations

- On-going collection of a minimum, accurate and adequate catches, effort, size frequency and age data
- There is a clear needed to collect catch and effort data for all months and areas where fishing is occurring and to take this information into account when developing CPUE series.
- Produce regular national updates of assessments to determine the status of stocks and desirable management measures such as suitable effort
- Collection of data for each month etc including data for pots and traps and trawls.
- Collaborate with countries such as Suriname, Venezuela and Brazil for stock assessments.
- Raise and compute length frequencies at various areas.
- Computerize all data that is relevant for the species

3.9 References

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4. The Lane Snapper (*Lutjanus synagris*) fishery of Trinidad and Tobago

Rapporteurs: Suzuette Soomai and Clay Porch

4.1 Management Objectives

General management objectives for the marine fisheries of Trinidad and Tobago were used as a guide to this assessment with particular note to the objectives that state:

- Ensure through proper conservation and management, that the fisheries resources are not endangered by over-fishing" and
- Ensure that the exploitation of the fisheries resources and the conduct of related activities, are consistent with ecological sustainability (e.g. for target and non-target species, and marine environments) (Fisheries Division and FAO, 1992)

4.2 Status of Stocks

Results of the assessment indicate a high fishing mortality rate, which may have affected the overall biomass however it appears that recruitment has not been affected. Results suggest that the landings of the lane snapper, *L. synagris,* are largely comprised of fish less than 2 years old and before they can spawn. Results also suggest that the population of *L. synagris* in Trinidad is not a unit stock, but part of a larger population on the adjacent continental shelf that is perhaps not so heavily exploited and supplies a steady stream of recruits into Trinidad waters.

4.3 Management Advice

The Working Group noted that there were data gaps that influenced the ability of the assessment to give good results. In view of the need to review the quality of the available data for the fishery there is no specific management advice at this time. In the short term fishing effort should be monitored and not allowed to increase.

4.4. Statistics and Research Recommendations

4.4.1 Data Quality

Data from Venezuelan fleets operating in the Gulf of Paria and the Colombus Channel need to be included in future attempts to evaluate the fishery.

Catch and effort data from the offshore fishpot fleet in Trinidad and Tobago need to be collected to obtain more representative statistical coverage of fishpot activities.

Catch per unit effort need to be derived from nominal data to eliminate biases, especially with regard to sampling area, which may occur from raising to total catches.

Total landings of the species need to be improved by extracting the information for *L. synagris* that is currently recorded under broad species categories or within mixed groups of fish.

4.4.2 Research

Studies on the local migration and distribution patterns of the lane snapper aimed at identifying the extent of stock distribution need to be undertaken. These studies will be able to corroborate the validity of the assumption that there may be constant recruitment and to determine possible factors contributing to the apparent high fishing mortality values.

Given the proximity of Trinidad to Venezuela, the extent to which the existing stocks in the Gulf of Paria and off the south coast of Trinidad are shared with Venezuela needs to be established. In this respect, it is recommended that joint length based assessments between Trinidad and Tobago and Venezuela for the snapper should be conducted.

There is also uncertainty as to whether the lane snapper caught by Trinidad and Tobago and other countries on the Brazil-Guianas Shelf belong to a unit stock. It is therefore recommended that length frequency data from the 1988 Fritdjof Nansen fish surveys in the region be sourced and assessed to help determine this. Tagging studies and aging of fish can be conducted to obtain estimates of mortality and selection to corroborate the results of this assessment.

4.5 Stock Assessment Summary

The analysis utilized recent (1995-2004), historical (1963, 1975) and reconstructed (1908 to current) annual catch per unit effort (CPUE) levels for artisanal gillnet, line and trawl fleets operating in Trinidad in addition to length data obtained from fishpot and banking (handline) in 1996-1997. Biological parameters were obtained from a previous assessment for the lane snapper in Trinidad (Manickchand-Dass, 1987).

The assessment utilized two programmes: (a) a mean size model that observed growth using the length frequency information (Gedamke and Hoenig 1995); and (b) a catch-free model that observed stock abundance trends and fishing mortality from CPUE information (Porch et al 2006).

(a) Mean size Mode:
Mean lengths showed that selection of fish from as early as age 1 was common and selectivity for fishpots and banking were similar after an age of two years. This implied that the availability of all fish sizes above 30 cm is the same for both gears in spite of their very different natures.

The truncated length composition data used in this model suggest a highly exploited population.

(b) Catch-free Model:
The stock was assumed to be only lightly exploited prior to 1950.Fishing mortality was estimated using the time series of reconstructed total landings as an index of relative fishing effort for the years prior to 1994.

CPUE indices for seven gears were examined. Five indices showed relatively flat trends (multifilament gillnet, monofilament gillnet, a la vive, semi-industrial trawl, banking). Two indices suggested recent increases in abundance (artisanal trawl, fish pot). Figure 1 shows the relative CPUE derived for artisanal gillnet, line, fishpot and trawl.

The estimates of fishing mortality and spawning biomass that were generated are somewhat uncertain and, contrary to the mean size model, they generally indicate a lightly exploited population that is well above the level that would produce the maximum sustainable yield with the current selectivity pattern.
The flat or increasing CPUE trends over time suggest that recruitment of ages 1 and 2 individuals to the fishery has not changed a great deal.

Overall, results indicate that there may be a constant recruitment to the lane snapper fishery in Trinidad since in spite of the high fishing mortality the CPUE trends are relatively constant. It is also possible that the rarity of larger animals in the catch is partly due to emigration out of the fishing area which was not accounted for in the mean size model and may have lead to over-estimates of fishing mortality.

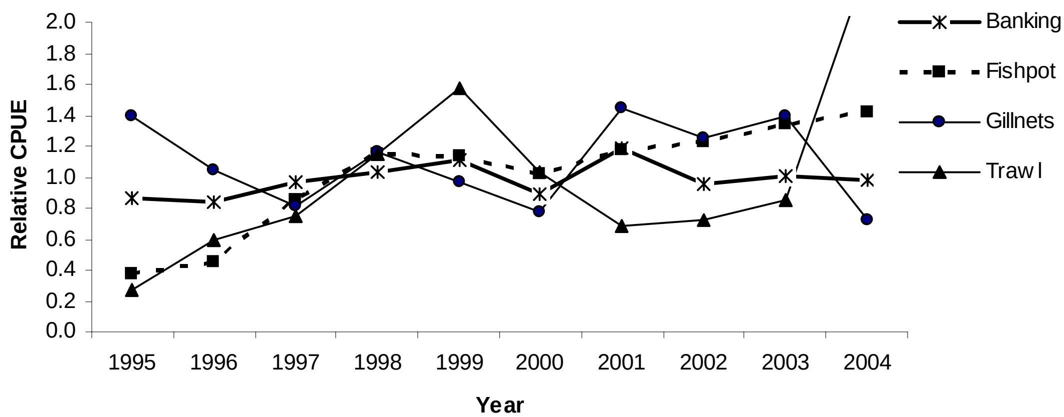

Figure 1: Relative catch per unit effort (CPUE) for artisanal gears including gillnets (monofilament and multifilament), lines (banking), fishpot and trawl (artisanal fleet only), for 1963, 1975 and the period 1995-2004.

4.6 Special Comments

None.

4.7 Policy Summary

Trinidad and Tobago is currently updating its fisheries policy. The management objectives and main policy directions as however outlined in the marine fishery policy document (Fisheries Division and FAO, 1994).

4.8 Scientific Assessment

4.8.1 Description of the Fishery

The snapper fishery is one of the country's most commercially valuable groundfish fishery. The species of main importance in terms of landings and value are *Lutjanus synagris* (lane snapper), *L. purpureus* (southern red snapper) and *Rhomboplites aurorubens* (vermilion snapper). Other species of lesser importance are *L. griseus* (grey snapper), *L. jocu* (dog snapper) and *L. vivanus* (silk snapper/vivanot).

Lutjanus synagris is more commonly associated with muddy-bottom substrates than the other snapper species, which are associated with hard-substrates and are mainly caught on the south-east coasts of Trinidad. *L. synagris* is landed predominantly on the south and south-west coasts of Trinidad, in the Gulf of Paria and the Colombus Channel, where environmental conditions are characteristic of the Brazil-Guianas Continental Shelf.

Snappers are exploited by the artisanal multigear (fishpots, lines, gillnets, trawl), the semi-industrial multi-gear (fishpots, lines) and the semi-industrial and industrial trawl and fleet which are described in the National Report for Trinidad and Tobago (Ferreira and Martin, 2005). A 2003 vessel census recorded 338 artisanal vessels using gillnets (170 monofilament and 168 multifilament) and 234 artisanal vessels using demersal lines (79 hand lines, 110 live bait lines, 45 demersal longlines). The trawl fleet was comprised of 102 artisanal trawlers, 10 semi-industrial trawlers and 20 to 25 industrial trawlers. The exact number of semi-industrial multigear vessels was not recorded.

The main gear used to target snappers is the fishpot/trap. Artisanal vessels operate in shallow coastal waters and use rectangular V or Z- shaped Antillean design pots with wooden or steel frames measuring

2m x 1.5m x 0.6m with 30mm hexagonal wire mesh walls and two 180x360mm openings. The semi-industrial fleet operates at depths of 55m-134m and uses arrowhead-shaped pots constructed of steel frames measuring 0.61m x 1.02m x 1.52m with 51mm hexagonal rubber mesh walls and a 0.61m-0.76m opening. The semi-industrial vessels entered the fishery in the 1980's and target snapper resources on the offshore continental shelf on the north and east coasts of Trinidad and off Tobago and almost exclusively supports the export market for red snapper (Mohammed et al. 2005. It is estimated that 86.2% of the snapper landings from fishpots on the south coast were dominated by *L. synagris* (Manickchand-Heileman and Phillip, 1993).

Line methods, primarily hand lines (banking) and demersal longline (palangue), catch significant quantities of snappers. Banking lines are weighted handlines with 1-20 hooks on branch lines off a main line made of monofilament nylon. Bottom-set palangue lines comprise a main line made of multifilament twine carrying 4000 to 5000 hooks A-la-vive lines utilize live bait and other bottom-set longlines are important to a lesser extent.

Gillnet and trawl land significant amounts of *L. synagris* as bycatch Gillnets are of two types, those made of monofilament nylon and those made of multifilament twine and are used in the coastal pelagic fishery for the mackerels. The trawl fleet is comprised of artisanal, semi-industrial and industrial vessels which target penaeid shrimp. *L. synagris* may sometimes be targeted by industrial trawlers during periods of consistently low shrimp catches.

Artisanal vessels operate year round in shallow coastal waters on one-day fishing trips. All trawlers operate year round in the Gulf of Paria on the west coast however industrial vessels also operate in the Columbus Channel on the south coast. Vessels from both Trinidad and Tobago and Venezuela exploit the snapper resources in the Gulf of Paria and the Columbus Channel. In the Columbus Channel the area outside of two miles from the coastline of Trinidad and Venezuela is designated a Joint Fisheries Management Regime Area under a 1997 bilateral agreement between the governments of Trinidad and Tobago and Venezuela.

Total annual landings of *L. synagris* for the period 1995-2004 were estimated at 483 tonnes with a value of US$1.5 million. This is considered an underestimate since there is no formal mechanism for collection of catch and effort data from the semi-industrial multigear fleet. Export data on lane snappers are often grouped with other snapper species as well as other fish species and as a result it is difficult to determine the exact quantities of snapper exported.

Previous studies on the biology of *L. synagris* were conducted using landings from the fish pot and trawl fisheries (Dass, 1983, Maingot and Manickchand-Heileman, 1987, Manickchand-Dass,1987). Results show that the species spawns throughout the year with a peak of activity from February to September and juveniles were present throughout the year. The ratio of male to female was approximately 1:1. Males mature at 37cm and females at 41cm and general growth and mortality parameters were estimated. A comparison of sizes caught by sex and gear type showed that trawl nets caught smaller fish and females were generally smaller than males for both gears. A yield per recruit analysis indicated that at all values of natural mortality (M), the lane snapper was under-exploited. At the estimated value of M and age of first capture (t_c) for this study a 462% increase in F (from 0.17 to 0.8 year-1) was predicted to give a 160% increase in yield per recruit (from 70g to 112g). General recommendations of the 1987 study were to increase the age of first capture from 1.38 years to 2 years at a total length of 30cm (above size at maturity of 22.5cm TL and 23.0cm TL for males and females respectively) and to increase F to 0.8 which would result in a YPR of 122g.

4.8.2 Overall Assessment Objectives

Considerable changes in fleet composition and fishing operations have occurred since 1987 when the last assessments for snappers (Manickchand-Dass 1987) were performed. It is therefore necessary that the assessments be updated to ascertain the current stock status and recommend appropriate management strategies.

4.8.3 Data Used

Catch and effort data were available for nine gear types namely artisanal gillnets (monofilament, multifilament); lines (banking, palangue, a-la-vive) and fishpots as well as artisanal and semi-industrial trawl for the period 1995 to 2004 and for the industrial trawl fleet for the period 2000 to 2004. Historical catch and effort data were also available for 1963 and 1975. Reconstructed catch and effort data from 1908 to 1999 were available from Chan-A-Shing 1994. Catch and effort data were collected for snappers at all the major fish landing sites around Trinidad. At these sites catch and effort data are collected for 20 randomly selected days each month and raised to account for non-enumerated fishing days and to non-enumerated sites.

Length frequency data *L. synagris* were available from June 1996 to July 1998 from artisanal gillnet, lines and fishpots and samples were obtained mainly from fish pots and banking lines. In addition, length frequencies for fish pots and trawl gear for November 1979 – June 1981 were reconstructed from a previous study performed on the snapper fishery in Trinidad (Manickchand-Dass 1987). This length data was obtained from the catch at major landing sites on the south and south-west coast of Trinidad. Length frequencies for *L. synagris* from trawl catches were available for 2004 and 2005 under a program of market and at-sea sampling of trawl catches to investigate bycatch and discards however the data were not utilized since the samples were not considered random since the catch was sorted into different size/landed categories and would require considerable formatting to be useful at this meeting.

Biological information for the *L. synagris* was obtained from FISHBASE and from the previous YPR analysis conducted using data from Trinidad (Manickchand-Dass 1987). It was noted that this resource is considered to be shared with Venezuela however no data were available at this meeting. Table 1 summarizes the data used in the assessment.

Table 1. Summary of data types and sources used in the assessment.

Data Type	**Fleets**	**Period**	**Source**
Catch and Effort	Artisanal Gillnets – monofilament, multifilament Artisanal Lines - banking, palangue, a-la-vive Trawl - artisanal, semi-industrial	1995 – 2004, 1975, 1963 (by month)	Beach landing statistics collected at all major landing sites around Trinidad.
	Industrial trawl	2000 - 2004 (by month)	
Catch	Artisanal fleets	1908 – 1999 (annual)	Chan A Shing 2002
Length Frequencies	Artisanal Gillnets – monofilament, multifilament Artisanal Lines - banking, palangue, a-la-vive	June 1996 – July 1998 (by month)	Fisheries Division
	Artisanal fishpots and trawl	November 1979 – June 1981 (by month)	Manickchand-Dass 1987

4.8.4 Assessment

4.8.4.1 Objective

To ascertain the current stock status and to recommend appropriate management strategies.

4.8.4.2 Method/Models/Data

The fishing mortality rate was estimated from the 1979 - 1981 and 1997 length frequency data using a modification of the mean-size method of Gedamke and Hoenig (1995) by C. E. Porch (unpublished Excel spreadsheet). This model is similar to that published by Beverton and Holt (1957), but allows the fishing mortality rate to vary through time and fits a series of annual mean-size observations. The main underlying assumptions are that growth follows a known von Bertalanffy relationship, selectivity-at-age is known (or constant beyond a certain age) and that recruitment has been relatively constant. Input parameters used in the model are given in Table 2.

The maximum observed age indicated on FISHBASE was 10 yrs, therefore the mean-size calculations included up to age 10. The selectivity/availability for each age group was not known. Inspection of the length frequency distribution for 1980, when the stock was believed to be lightly exploited, reveals that the peak is about 28 cm, which is somewhat less than the size, expected for age 2 fish. Moreover, the shape of the length frequency distributions for fish pots and banking (hooks) are very similar for fish greater than 30 cm (Figure 2). This implies that the availability of each size class is the same for both gears, which given the very different nature of the gears, implies all sizes above 30 cm may be equally available. Therefore the mean-size approach was applied with constant selection starting at age 2. Use of the mean-size approach also requires the mean to be computed from the observed length-frequency data pertaining to age classes greater than or equal to the first age in the analysis (here age 2). This requires truncating the length-frequency data at the minimum size associated with age 2, which in this case is uncertain. The growth curve indicates that the expected length at age 2.0 is 30 cm; however, owing to variations in length at age it is probable that some age 1 animal exceed 30 cm and some age 2 animals are less than 30 cm. An appropriate truncation point would be where the overlap between the two age classes balances out, but this is difficult to determine owing to the lack of information on age. Hence, runs were made using alternative truncation points at 28, 30 and 32 cm.

Fishing mortality and stock abundance trends were also estimated from series of CPUE and relative effort (derived from the historical landings series) using the catch free approach of Porch et al. (2006). This model is essentially an age-structured production model recast in terms relative to pre-exploitation levels. For this reason it does not require catch or absolute measure of abundance. The growth and natural mortality parameters used are the same as for the preceding mean-size analysis. Recruitment is modeled as deviations from a Beverton and Holt stock recruitment relationship (with a cv of 40%) that has been re-parameterized in terms of the maximum lifetime fecundity (α). A prior density was specified for α (median and variance) based on the values published in Myers et al. (1999) that correspond to species with life history strategies similar to *L. synagris*. To date there are insufficient data for estimating a fecundity-at-age relationship for *L. synagris*, therefore weight-at-age was used as a proxy. The stock is assumed to have been only lightly exploited prior to 1950. Subsequent effort is assumed to track the time series of reconstructed total landings as an index of relative effort for the years prior to 1994. Fishing mortality during this period is then estimated as a scalar multiple of the relative effort (i.e., by use of a catchability coefficient). After that the fishing mortality rates could be estimated independent of the relative effort series owing to the availability of several time series of CPUE (presumably indexing relative abundance). Inter-annual variations in fishing mortality were mildly constrained via a lognormal penalty with a cv of 40%.

Two separate models were developed. Model 1 used five indices with relatively flat trends (multifilament gillnet, monofilament gillnet, a la vive, semi-industrial trawl, and banking). Model 2 used two indices that suggested recent increases in abundance (artisanal trawl and fish pot).

Table 2. Input parameters for the mean size model.

Input Parameters	**Values**	**Location**	**Sources**
Von Bertalanffy Growth:		Trinidad and Tobago	Manickchand-Dass 1987
K ($year^{-1}$)	0.27		
L_∞	66.7 cm		
t_o	-0.19		
Natural Mortality: M ($year^{-1}$)	0.59		
Length-weight relationship:		Brazil	Nomura 1965
A	0.0427		
B	2.72		

4.8.4.3 Results

The average lengths computed from the banking length frequency distributions truncated at 28, 30 and 31 cm are shown for each year in Table 2. The corresponding estimates of fishing mortality for are summarized in Table 3.

A yield per recruit analysis was conducted assuming 50% selection at age 1 and 100% selection thereafter. The results are summarized in Figure 3.

Both catch-free models provided reasonable fits to the CPUE indices (Figures 4 and 5), although the fluctuations for individual years were not matched very well because they differed among the indices. The estimates of fishing mortality and spawning biomass are somewhat uncertain, but generally indicate a lightly exploited population that is well above the level that would produce the maximum sustainable yield with the current selectivity pattern (Figures 6 and 7).

Table 3. Mean, variance and number of observations for length frequency distributions from the hook and line fishery for red snapper using only lengths above 28, 30 and 32 cm.

	28 cm cutoff			30 cm cutoff			32 cm cutoff		
Year	Mean	Var	No.	Mean	Var	No.	Mean	Var	No.
1980	32.74	1054.3	695	34.29	1154.9	219	36.35	1295.4	135
1997	31.52	971.6	1130	33.22	1078.8	680	34.99	1197.3	377

Table 4. Estimates of fishing mortality rate by year obtained by fitting to mean size data truncated at 28, 30 and 32 cm.

	28 cm cutoff		30 cm cutoff		32 cm cutoff	
year	Const.	Var	Const.	Var	Const.	Var
1980	3.69	2.50	1.84	1.35	0.94	0.66
1997	3.69	4.84	1.84	2.03	0.94	1.05

4.8.4.4 Discussion

Overall, the assessment appears to indicate that growth overfishing is occurring in that the fishing mortality rate is probably greater than that which would produce the maximum yield per recruit. Continued fishing at this high level also implies a belief that future recruitment will continue at current levels. If recruitment is in fact dependent on local spawning biomass, then the current level of fishing may lead to recruitment overfishing.

It is possible that the rarity of larger animals in the catch, which is interpreted as very high fishing mortality rates, is partly due to emigration out of the fishing area. In effect, such emigration acts in the same fashion as an increase in natural mortality from the standpoint of the model. Even so, the fact that the length frequency distribution from 1997, a period of high fishing, is much more severely truncated than the distribution for 1980, a period of relatively less fishing, is evidence that fishing mortality has had an important on the population.

The catch-free model interprets the flat/increasing CPUE trends as indicative of a lightly exploited stock that is well above the level that would produce the maximum sustainable yield. In effect, the model finds light exploitation rates as the best solution for reconciling the rapid increase in relative effort seen during the late 1980s and early 1990s with the flat/increasing CPUE trends observed since 1965. The prior on the maximum life time fecundity parameter prevents recruitment from becoming completely independent of stock size, thereby constraining the only other means the model would have to reconcile those trends. The constraining effect of this prior would presumably have been mitigated if the length frequency data were included in the catch-free model, in which case the model would likely have been forced to recognize high fishing mortality rates and estimate recruitment independent of stock size (near the limit).

The different pictures of stock status afforded by the length frequency and CPUE data suggest that the population of *L. synagris* in Trinidad is not a unit stock, but part of a larger population on the adjacent continental shelf that is perhaps not so heavily exploited and supplies a steady stream of recruits into Trinidadian waters. It might be argued that the flat or increasing trends in the CPUE reflect am increase in efficiency and mask an actual decline in abundance trends, but this is unlikely to be true for all seven of the indices examined. In most of the CPUE series *L. synagris* appears as an incidental bycatch (trawls, gillnets) and in others it is targeted along with many other species using fishing practices which have not changed much since the 1950s (artisanal pots, banking). Only the a la vive index (live bait fishing for pelagic fishes) shows what might be interpreted as a consistent decrease, but very few *L. synagris* are caught by that fishing method.

Previous stock assessment studies indicated that too many young lane snapper were being caught, leading to a decrease in yield and potentially a collapse of the stock as too few fish were allowed to reach reproductive maturity. The management strategy recommended was to increase the mesh size to that which will maximize yield and prevent overfishing. The information available for the present assessment corroborates these earlier conclusions, suggesting that the landings of lane snapper less than 2 years old needs to be curtailed. Specific research on gear selectivity is needed to determine the optimal mesh size for traps and other gears that capture lane snapper. Moreover, research is needed to determine the uniqueness of the stock in Trinidad waters and whether or not there are any ontogenic movement patterns that might make lane snapper less vulnerable to the gear and cause fishing mortality to be over-estimated. It is also important that other countries sharing the same continental shelf participate in this assessment so that a more accurate picture of the resource might be gained.

4.9 References

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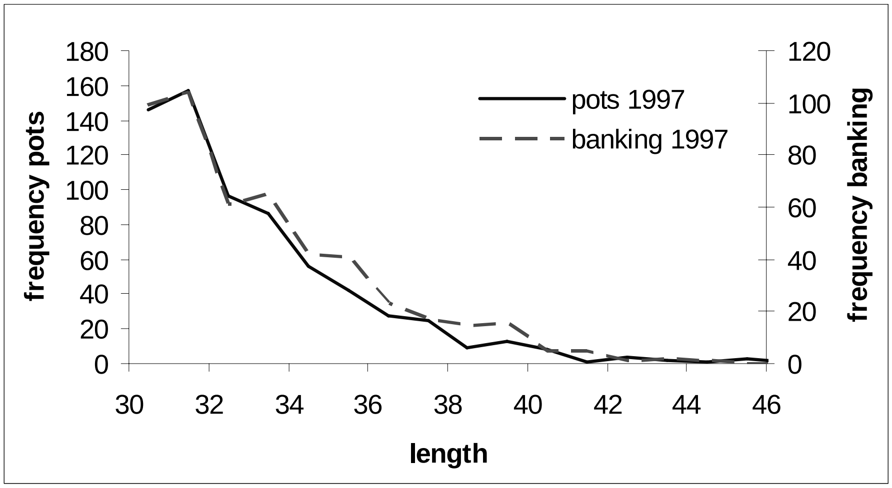


Figure 2. Length frequency distributions for pots and banking in 1997 truncated at 30 cm.

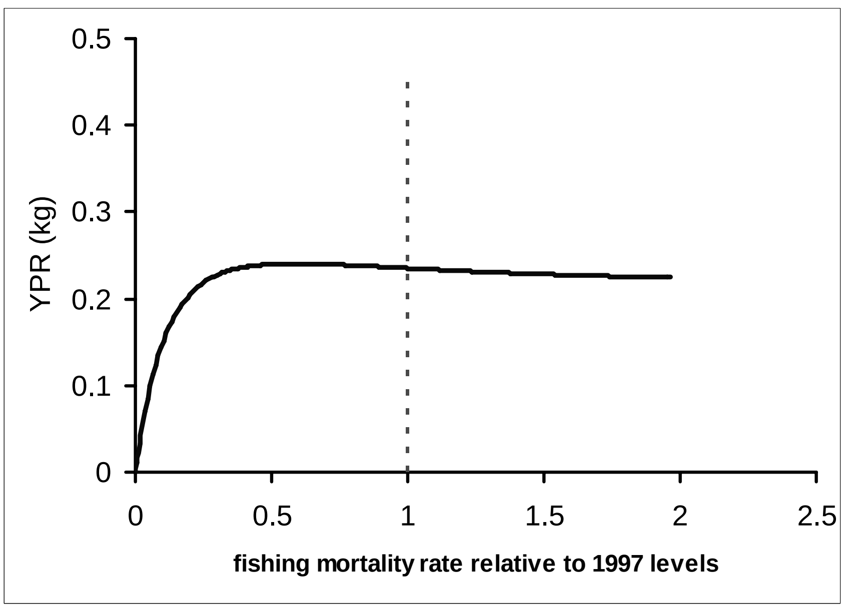


Figure 3. Yield-per-recruit estimated assuming 50% selection for age 1 and 100% selection for age 2 and older. The horizontal axis may be interpreted as effort levels relative to the 1997 level estimated under the corresponding assumed selection patterns.

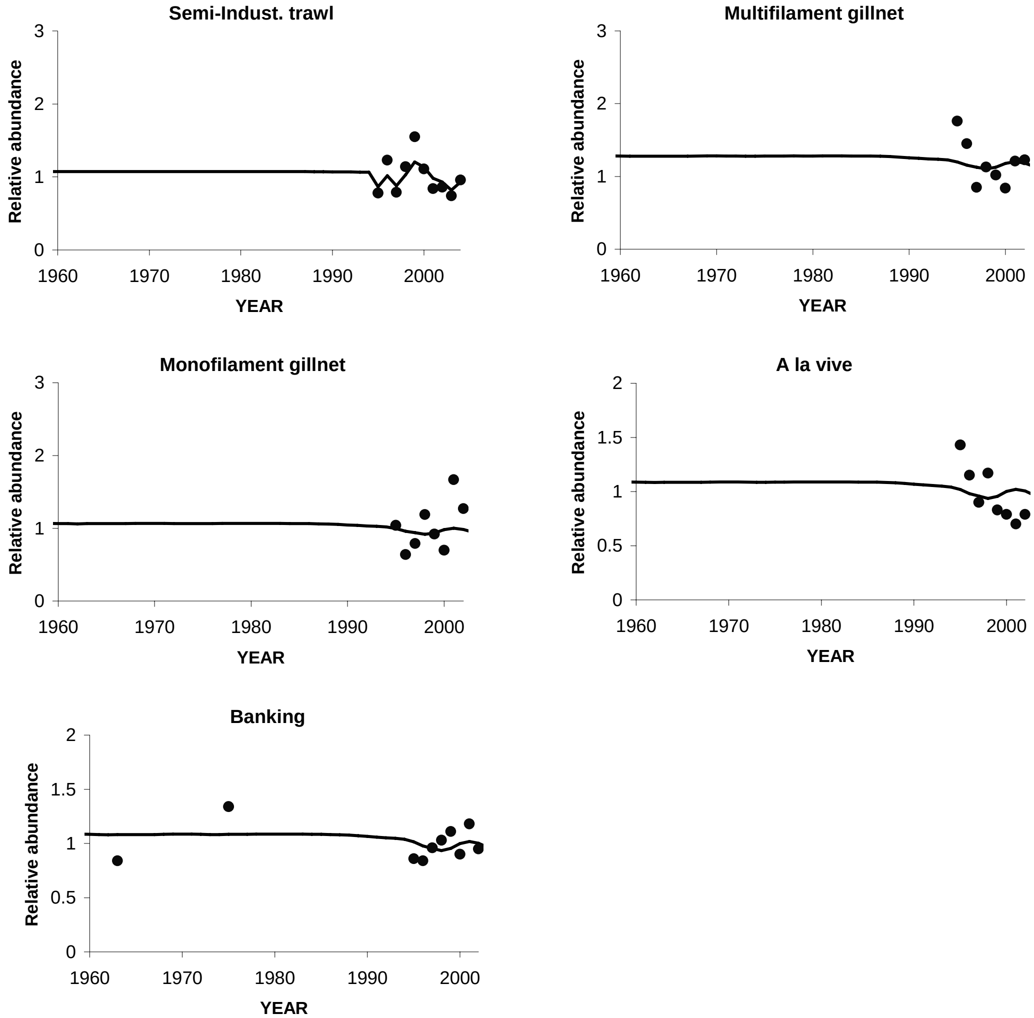


Figure 4. Model 1 fits to the CPUE indices.

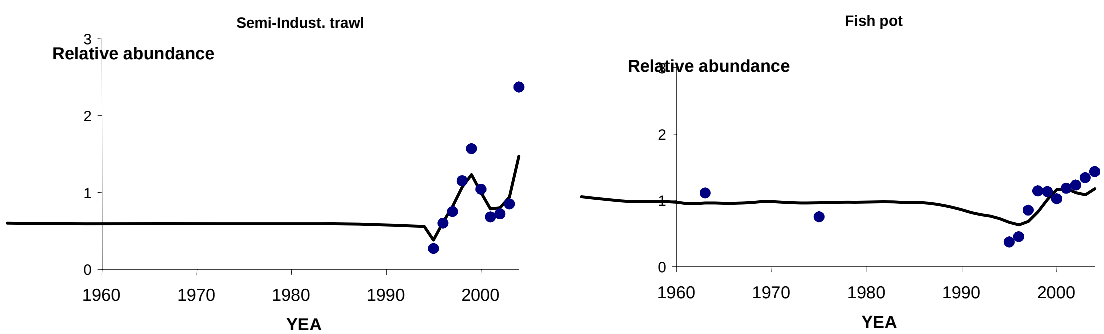


Figure 5. Model 2 fits to the CPUE indices.

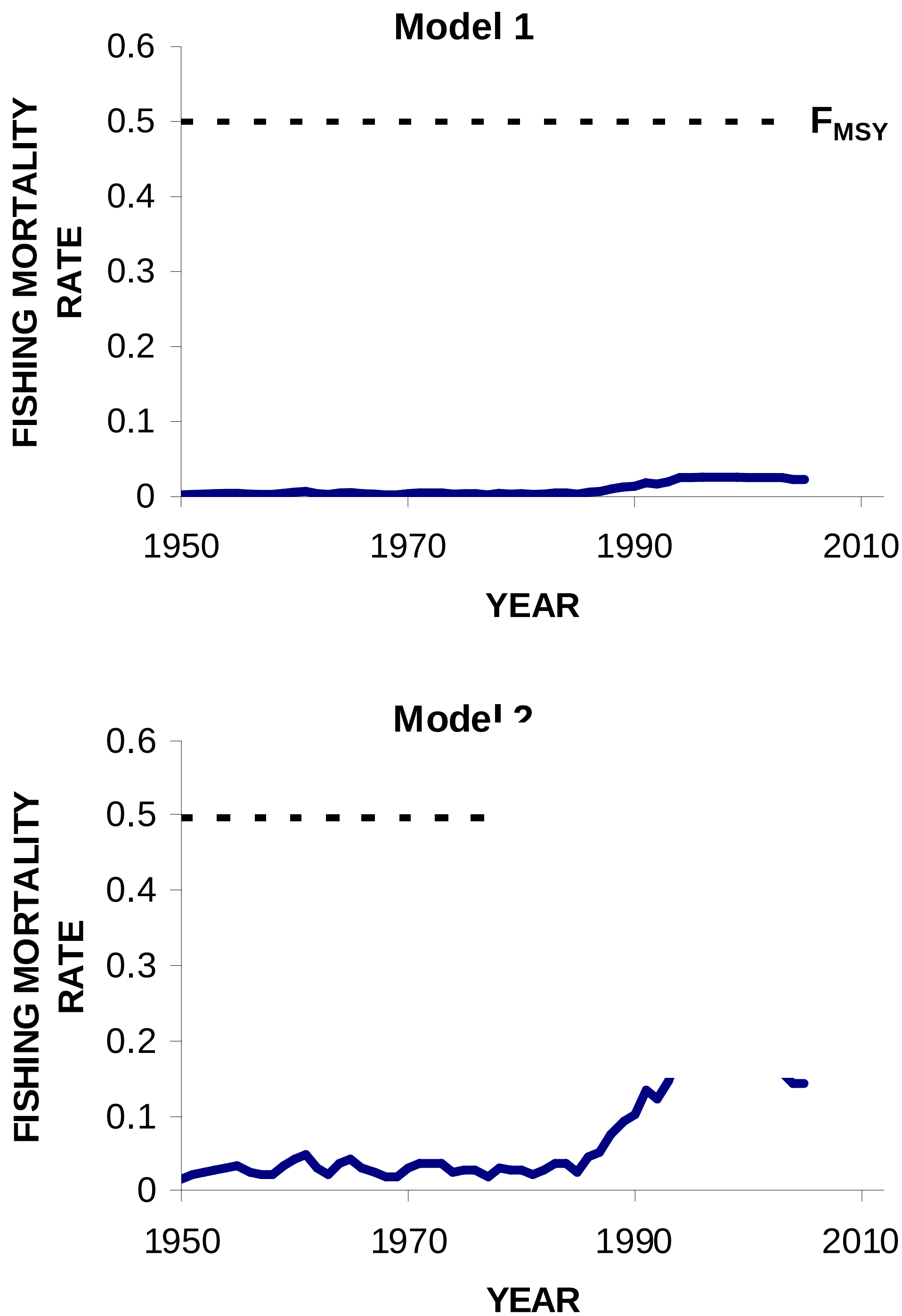


Figure 6. Estimated trends in fishing mortality rate from model 1 (top) and model 2 (bottom).

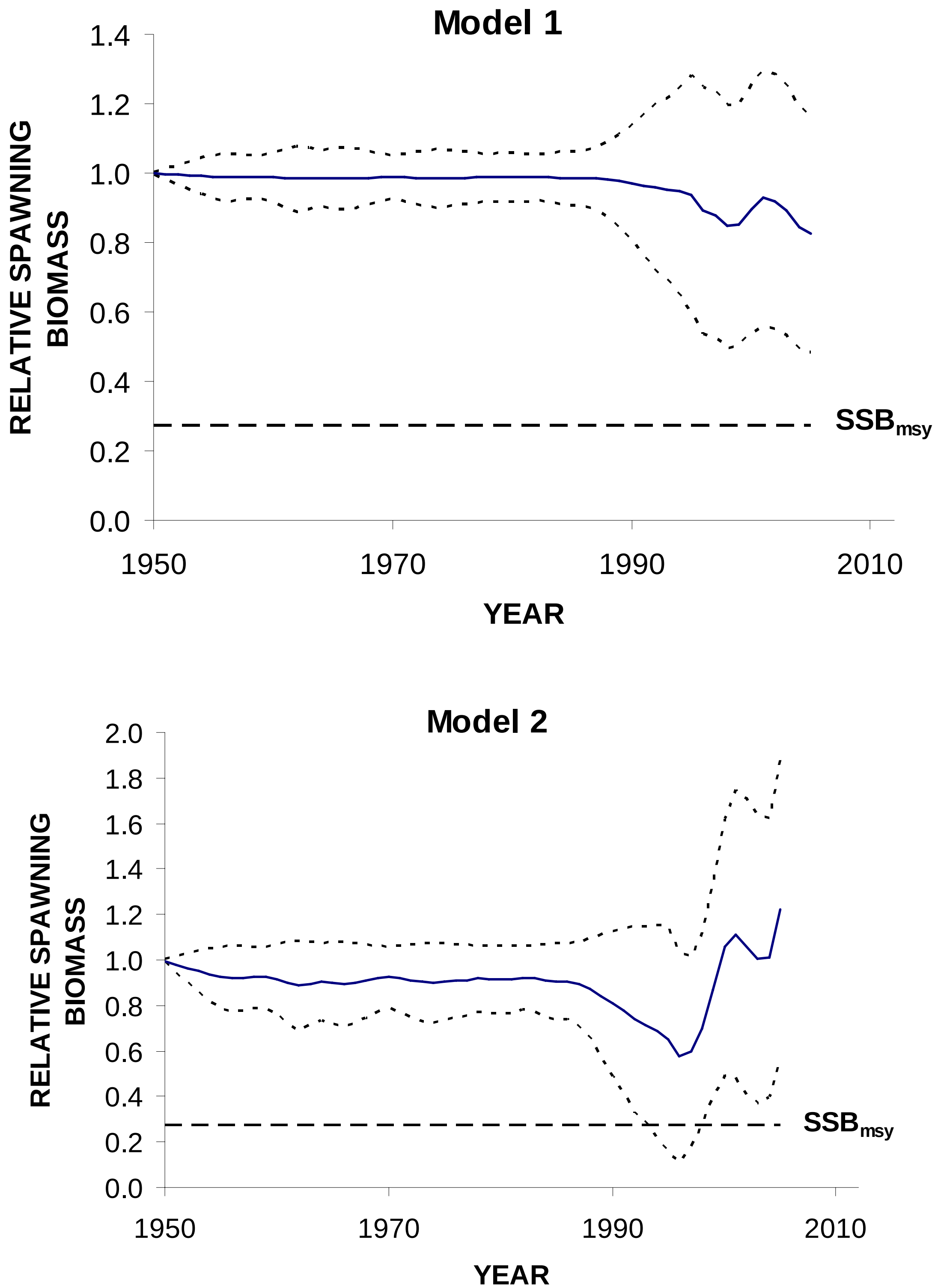


Figure 7. Estimated trends in spawning biomass (relative to unfished levels) with 80% confidence levels from model 1 (top) and model 2 (bottom).

Appendix 7: Report of the Large Pelagic Fish Resource Working Group

A. OVERVIEW

As agreed at the plenary session of the 1st Annual CRFM Scientific assessment meeting held in St. Vincent in 2004, the Large Pelagic Fisheries Working Group for this the 2nd Scientific Assessment workshop consisted of Mr. Christopher Parker (Barbados) as Working Group Chairman and species rapporteur for dolphinfish and Ms. Louanna Martin (Trinidad and Tobago) as rapporteur for king mackerel.

At this meeting, Dr. Daniel Hoggarth (SCALES - Great Britain) and Dr. Joshua Nowlis (Southeast Fisheries Science Center - USA) were the assessment advisors attached to the Working Group. Kristen Kleisner (RSMAS - USA), a student of Dr. Nowlis, also participated in the working group.

During the period of work the entire Working Group met formally on three occasions to discuss common issues.

- The first order of business for the group was the formation of individual species assessments groups. It was agreed that Dr. Nowlis and Ms. Kleisner would work with Mr. Parker on dolphinfish and Dr. Hoggarth would work with Ms. Martin on King Mackerel assessment. It should be noted that Serra Spanish mackerel was not assessed at this meeting as the information recommended at the 1st scientific meeting for advancing the assessment had not yet been obtained.
- The group agreed that decisions pertaining to the most appropriate data analyses to be conducted on the two species being assessed would be left to the species assessment sub-groups and would be mainly controlled by the type and quality of available data.
- It was agreed that the individual species assessments would be reported in separate documents following the format previously used for the 1st scientific meeting.

During the course of the meeting the group agreed on a number of issues that they considered should be raised at the general workshop plenary session. Following is a brief summary of these points. It should be noted that the more detailed recommendations, related more directly to the individual species assessments are presented in the species assessment reports.

- It was agreed that the group would include crevalle jack as species for assessment in the future given that this species is taken as a bycatch in the large pelagic fisheries. The working group attempted to list all the species that should be covered by the group. However, the working group decided to defer completion of the list to the plenary.
- In the case of dolphinfish it was agreed that the work being conducted by Ms. Kleisner would prove very beneficial to future assessments of this species once she has completed her work. As such it is proposed that another assessment of dolphinfish should be scheduled for 2007 provided that the results of Ms. Kleisner prove to be useful and available in time.
- The Working Group discussed briefly the need to contribute to ICCAT assessment activities covering the highly migratory large pelagic species of interest to CRFM member states.
- The Working Group should also contribute data to ICCAT and promote assessment of the small tunas and tuna-like species of interest to CRFM members (e.g. wahoo, blackfin tuna, king mackerel and Spanish mackerel) at ICCAT through active representation and participation by CRFM scientists in ICCAT SCRS meetings.
- Given the points listed above it was agreed that decisions on the timing for species stock assessments and indeed the forums for these assessments should be taken at the plenary.

- It was also agreed that the CRFM should consider the formation of a Scientific Committee to guide the working groups and to report to the Forum.

Ms Rosemarie Kishore of the IMA was invited to give a presentation of her Institute's work on using hard parts analysis primarily for crevalle jack and some aspects of ageing of wahoo and Spanish mackerel.

- The working group agreed that the work on aging conducted by the IMA would be useful in assessing large pelagic stocks and that the CRFM has to enhance its working relationship with the IMA both in respect of funding and future collaborative research.

B. FISHERIES REPORTS

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

Rapporteurs: Louanna Martin (species rapporteur, Trinidad and Tobago, Fisheries Division) and Dan Hoggarth (Consultant, Scales Consulting Ltd)

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 includes Serra Spanish mackerel (*S. brasiliensis*) 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 fisheries management plans).

In Guyana, the management objectives for the large pelagic fishery are 'to develop the capacity for maximizing 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' (Guyana national report as submitted to meeting). 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 and around the Dominican Republic and Florida.

Given Trinidad and Tobago's stated objective of 'maintaining the sustainability of resources', guidance on the status of the stock is provided relative to the $F_{20\%SPR}$ reference point. This is the estimated value of the fishing mortality rate (or fishing pressure) that would reduce the spawning stock biomass per recruit to 20% of its level in an unfished stock. Fishing at higher than this rate has been found to cause recruitment failures in many well-studied stocks around the world. It is thus suggested as a limit reference point or threshold which should not be exceeded. It represents a higher level of fishing pressure than that suggested to achieve the maximum sustainable yield (for which $F_{40\%SPR}$ or $F_{30\%SPR}$ are commonly used) (Gabriel and Mace, 1999).

Fishing mortality rates were estimated for Trinidad and Tobago using available data for the combined 3-year period 1996-98 and for 2004. Separate estimates were made for two different growth models, both of which gave equally good fits to the data. As shown in Table 1, the 1996-98 fishing mortality rates were either 16% below or 80% above the $F_{20\%SPR}$ reference point, depending on which model was used. The 2004 estimates of fishing mortality rates, however, were much higher, with both models suggesting that the fishery is operating far beyond the levels of the threshold $F_{20\%SPR}$ reference point (i.e. 85-202% above, see Table 1).

Table 1. Comparison of estimated recent fishing mortality rates with the estimated 'threshold' or limit reference point levels, for the combined 1996-98 data set and the 2004 year, and for the two growth model fits used in the analysis. Values in brackets show the F indicators as percentages of the reference points.

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 year 2004
Low $L_{infinity}$	0.80	0.67 (84%)	1.48 (185%)
Medium $L_{infinity}$	0.66	1.19 (180%)	1.99 (302%)

1.3 Management advice

The analysis suggests that reductions in the fishing mortality rate by as much as two-thirds may be required to reduce the risk of stock collapse (i.e. to bring fishing pressure down to the 20% threshold of $F_{20\%SPR}$). As a possible alternative, a six month closed season would increase the relative spawning stock biomass per recruit (%SPR) from the 10% currently estimated in the medium $L_{infinity}$ model up to 22%. Increasing the size at first capture in the fishery (e.g. by enforcing fish and/or mesh size limits) from the current 50cm up to 60cm would also raise %SPR up to 19%. Such management measures have been identified as possible management options in Trinidad and Tobago, in addition to introducing a limited entry regime to replace the current free access. Combinations of such measures could be used to achieve the necessary adjustment. Further options could be investigated as requested.

Due to the uncertainty in which of the two growth models is most appropriate, and recognizing the small sample sizes used in estimating the 2004 mortality rates (see detailed report), the group recommends that the fishery is re-assessed as soon as possible to confirm or update this management advice. In the meantime, no increase in fishing pressure should be permitted until stock dynamics are better understood. Collection of additional length frequency data from non-selective gears in the 2006 season should enable the uncertainty in the assessment to be reduced, and also clarify whether the current fishing mortality rates are really as dangerously high as estimated in this assessment. Since the highest catches are taken in the two middle quarters of the year, sampling should begin immediately (see data needs below).

For this wide-ranging species, effective control of exploitation levels will require the cooperation of all states sharing each local (sub-)stock. No national or sub-regional regulations are currently in place on the numbers of fishing effort units allowed on southern stocks of king mackerel, though some size and gear restrictions are in place. Although ICCAT provides regional coordination for Atlantic tunas, no specific regulations are set for king mackerel, which, on a wider-regional scale, is one of the less important stocks. ICCAT (2005) endorses the need for a sub-regional approach for this species. The northern Caribbean stocks are managed by the US management councils, at least within US territorial waters. Given the importance of king mackerel to the southern Caribbean CRFM countries, and the assumption of a widely distributed and shared stock, it is proposed that the CRFM should continue to promote the participation of neighbouring non-member states in the scientific meeting. Prior to such participation CFRM member states should promote the assessment of the species at the ICCAT meetings, where other relevant states are represented.

1.4 Statistics and research recommendations

1.4.1 Data quality

The Trinidad and Tobago data were found to contain few errors and to be highly appropriate for the stock assessment needs. Problems exist more in the availability of the data (e.g. due to missing years or time periods) than with data 'quality'.

Catch and effort data were available for Trinidad and Tobago at the 'raw' trip interview level, but not for the other countries. Original 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 computerized. 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.

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 as available in the ICCAT observer database). In order to allow for zero catches in the abundance estimates, databases should include trip records from fishing gears which target king mackerel (or other pelagics) even when they did not catch the species on that trip.

For the reliable analysis of long-term time series of catch and effort, 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 on the stock and need to be accounted for in assessments.

The discrepancies in pre-1963 total catches reported by FAO and ICCAT for Venezuela also need to be resolved (see technical report).

The Trinidad and Tobago length frequency data were found to be potentially valuable in estimating both growth and mortality rates for this species. Continued sampling of length frequencies is encouraged, both in 2006 and future years to monitor fishing mortality rates. Samples of approximately 200 fish per gear type per month should be collected from those line-based gears that appear to catch the widest size ranges of fish (e.g. a-la-vive, switchering and trolling). Fish caught in beach seines should also be measured when sampled, as these were found to include the 'young of the year' fish, and therefore provide valuable information on the origin of the growth curve. Length frequencies from the highly selective gill net gears provide little information on growth or mortality rates and sampling of these gears may be discontinued (unless required to monitor changes in selectivity if mesh sizes are changing).

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 indicator.

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. If feasible, fishing mortality rates may then be estimated using the more powerful age-based methods.

1.5 Stock assessment summary

- Catches in recent years have been at historical high levels of 4-7 000 t. The largest catches are reported as being taken by Venezuela (and Brazil) in most years.
- Detailed analysis of the catch/effort data was postponed until the outstanding historical data records from Trinidad and Tobago have been entered, and the true values of the early Venezuelan catches have been confirmed.
- The parameters of the von Bertalanffy growth model were estimated from the Trinidad and Tobago length frequency data. Although the length frequency data had clear modes believed to represent age classes, the analysis was unable to reliably determine between two similar growth model fits, a low-$L_{infinity}$ model (129cm, associated with a K of 0.35), and a medium $L_{infinity}$ model (155cm, associated with a lower K of 0.30). Further analysis of the data set is warranted and reassessment based on any new length data.
- Total mortality rates were estimated in the range 1.13-1.76 for the 1996-98 data set, and at 1.63-2.90 for 2004. Natural mortality rates estimated at 0.51-0.59 were subtracted from these values to give the reported F estimates. The total length frequency sample size used in 2004 (n=558 from the 'low selectivity gears) is less than that used for the 1996-98 data set (n=2200), and so the 2004 estimates are considered less reliable.
- The $F_{20\%SPR}$ and $F_{0.1}$ reference points were estimated using the FMSP 'Yield' software, as were the potential effects of alternative closed seasons and size limits.

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 coastally distributed large pelagic species should be coordinated among neighbouring countries sharing these sub-stocks. Options for assessing and managing the stock in collaboration with Venezuela, Brazil and any other relevant countries should be explored, including at ICCAT meetings.

1.8 Scientific Assessments

1.8.1 Fishery Description

1.8.1.1 Fishing activity

Throughout its geographic range in the Western Atlantic from the north-eastern coast of the United States to Rio de Janeiro, Brazil, king mackerel is important in commercial and recreational fisheries (Collette and Nauen, 1983). It is highly valued among finfish species in Trinidad and Tobago and is targeted at annual game fishing tournaments (Henry and Martin, 1992). Estimates of annual ex-vessel value for the Trinidad artisanal fleet ranged between US$ 1.1M and 2.8M and averaged 1.6M from 1995 to 2004.

In the United States and Brazil, king mackerel is caught commercially by hook and line gears as well as gillnets (Collette and Nauen, 1983). The same is true of Trinidad and Tobago. In Trinidad, the species is targeted by the pelagic hook and line components of the semi-industrial multi-gear fleet and the inshore artisanal multi-gear fleet (the major landings are by trolling and 'a-la-vive' fishing, a hook and line method with live bait). It is also a primary by-catch of the gillnet component of the inshore artisanal fleet which targets Serra Spanish mackerel (*S. brasiliensis*) (Henry and Martin, 1992). King mackerel is also captured in Trinidad by seines. In Tobago the primary methods targeting the pelagic species including

King mackerel are trolling or towing, ‘a-la-vive’ and drifting or lurking (Thomas *et al.*, 2001). A description of the drifting method was provided by Thomas *et al.* (2001). Drifting lines are floating lines made of corlene or nylon, about 200-300 ft long that are deployed during flyingfish fishing operations. The drifting lines are deployed while the monofilament gillnets targeting the flyingfish are soaking. In the drifting operation flyingfish is used as bait. The lines are deployed from the same side of the boat as the gillnet used to catch the flyingfish. When large pelagics are close to the vessel a short line, ‘little man’, is used to catch the fish, a practice called ‘spranging’. The baited line is tossed close to the moving fish and retrieved very fast thereby teasing the fish in an effort to catch it. A ‘gaff’ is used to get the fish aboard when it is too heavy to be lifted with the line. This drifting practice or ‘lurking’ employs 6 to 7 drift lines or handlines per vessel. Fishers from the south west of Tobago (Pigeon Point) to the north (Charlotteville) employ the method.

1.8.1.2 Biology

King mackerel is an epipelagic species that inhabits coastal waters along the continental shelf and outer reef areas (Collette and Nauen, 1983). The species grows to a maximum size of 173 cm (FL) and can weigh up to 45 kg. Growth parameters have been estimated for the species for several US localities (Gulf of Mexico, Atlantic, Florida) as well as in Mexico, Cuba, Brazil and Trinidad and Tobago. Estimates of asymptotic length ($L_{infinity}$) range between 90.3 and 153 cm (FL).

The king mackerel diet consists mainly of fishes including: clupeids, jack mackerels (Carangidae), snappers (Lutjanidae), grunts (Pomadasyidae), and half-beaks (Hemiramphidae); and smaller quantities of penaeid shrimps and squids (De Vane, 1978 and Naughton and Salomon, 1981, cited in Collette and Nauen, 1983). Spawning occurs between May and September in the western Gulf of Mexico (McEachran, Finucane and Hall, 1980 cited in Collette and Nauen, 1983) and from April through September in the northeastern Caribbean (Erdman, 1977). In Trinidad and northeastern Brazil the spawning was observed to occur throughout the year peaking from October through March (Sturm and Salter, 1990; Gesteria and Mesquita, 1976). Spawning begins for both sexes at age I-II (Sturm and Salter, 1989).

1.8.1.3 Distribution, Migration and Stock Structure

King mackerel is distributed in the western Atlantic from Massachusetts, USA to Rio de Janeiro, Brazil (Collette and Nauen, 1983). The waters from Florida to Massachusetts are inhabited only during the warm months of the year (Collette and Nauen, 1983). The species has been reported in the mid Atlantic at St Paul’s Rocks (Lubbock and Edwards, 1981 cited in Sturm and Salter, 1990).

Management of the resources in United States waters is based on a hypothesis of two migratory stocks: one stock in the Atlantic, southeastern United States, the other in the Gulf of Mexico. The hypothesis is compatible with the results of a genetics study by Gold *et. al.* (2002). Johnson *et. al*. (1994) suggest that there are two stocks in the Gulf of Mexico: a western stock that migrates during spring and early summer northward along the Mexico-Texas coast from winter grounds around the Yucatan Peninsula; and an eastern stock that migrates during the same time northward along the eastern coast of the Gulf of Mexico from winter grounds in south Florida (Gulf of Mexico and Atlantic Coast). Sutter *et. al*. (1991) observed similarly that king mackerel migrated annually from southern Florida in the spring towards the northeastern Gulf of Mexico waters, continued westward during the summer and returned to southern Florida by winter.

Research on defining the stock structure of King mackerel in the Caribbean is limited. Singh-Renton (1996) infers a difference between North American and Caribbean stocks from the literature.

1.8.1.4 Summary of previous stock assessment work

A preliminary assessment based on a surplus production model using Trinidad and Tobago catch and effort data and total catches reported to FAO and ICCAT was attempted in 2005 (Martin *et. al.* in prep.). Age-based stock assessments are conducted by the United States for the coastal waters of southeastern Untied States and the Gulf of Mexico (ICCAT, 2005).

1.8.1.5 Fishery management

Management recommendations specific to king mackerel have not been developed by ICCAT. ICCAT recommends that the species could be managed sub-regionally. Size and gear restrictions are in place in Trinidad and Tobago (king mackerel minimum size 12 in; maximum gillnet length 900 ft, maximum gillnet width 15 ft; gillnet mesh minimum diagonal stretched mesh 4.25 in) though they are not enforced. King mackerel in United States waters (off the east coast and in the Gulf of Mexico) are managed jointly by the Gulf of Mexico Fishery Management Council and the South Atlantic Fishery Management Council (Gold *et al.* 2002, Johnson *et al*. 1994, Powers and Thompson 1993). King mackerel in waters off Puerto Rico and the United States Virgin Islands are also managed by the United States. Information on fishery management in Suriname, Venezuela, French Guiana and Brazil was not available at the time of report preparation.

1.8.2 Total catches

1.8.2.1 Objective

Information on total catches was examined to determine the historical pattern of exploitation of the stock by different countries, and their relative importance in the fishery. Total catches may be used as a rough indicator of the likely fishing pressure on the stocks, bearing in mind that the variations in total catches over time may be due to changes in fishing effort, catchability (the efficiency of the fishing fleet) or stock sizes. Increasing total catches may thus reflect either good recruitment into the fishery, or increasing fishing pressure. Over short time periods, recruitment variability may be the main determinant of catch rate changes, while over a long time period, fishing pressure and catchability may be the main effects measured. Catch per unit effort data were also examined as indices of fish abundance (see following section).

1.8.2.2 Data used and methodology

Estimates of total catches from both the ICCAT and FAO databases (available on-line up to 2004 at the time of the meeting) were examined, in addition to catch data from Trinidad and Tobago, recently adjusted to improve the estimates of artisanal catches (and therefore differing from the records in the FAO database).

1.8.2.3 Results and discussion

The FAO and ICCAT sources report the same data for some years, but have some important differences in other years, particularly for Venezuela. For the FAO catches shown in Figure1, Venezuela catches in the 1950s and early 1960s were up to 3-4 000 tonnes. In the ICCAT database, Venezuela catches are reported as zero up to 1963, and increase gradually from that point, giving a substantively different picture.

As noted earlier, it is not clear whether the Brazilian catches should be regarded as taken from the same stock as those in southern Caribbean waters.

Trinidad and Tobago catches peaked at 2 600 tonnes in 1993 to dominate the fishery at that time, but have since fallen to around 500 tonnes per year.

Although Trinidad and Tobago catches have fallen from their historical peak, total catches now appear to be at historical high levels.

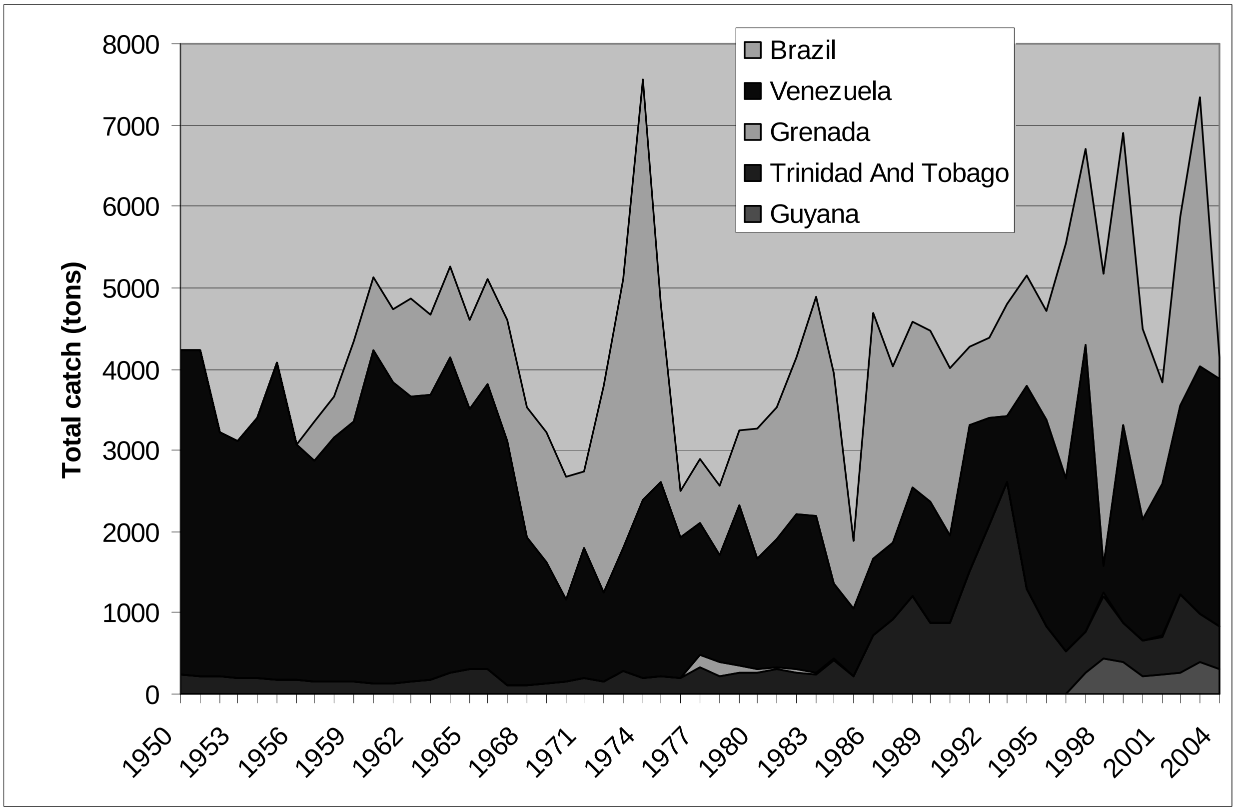


Figure 1.Total king mackerel catches by country for years 1950-2004, as reported in the FAO FishStat+ database, including recent adjustments to the Trinidad catches for artisanal fishing. Venezuela catches are given as zero in the ICCAT database for 1950-63.

1.8.3 Catch rates (abundance indices)

1.8.3.1 Objective

Catch rate data (CPUE) are commonly used as an index of the abundance of the fish stocks. Data on fish abundance and total catches are used in 'biomass dynamic' or 'surplus production' modeling (see below) to estimate current stock sizes and maximum sustainable yield. CPUE data are only likely to provide a good index of abundance if fishing practices and locations have remained relatively constant over time, such that the catchability of the gear is also constant.

1.8.3.2 Data used and methodologies

Catch and effort data were analyzed from the Trinidad trip records database, as available for the years 1963 to the present time. Total catches were extracted from the database by gear type and month, along with two effort measures, 'Days at Sea' and 'Man Days', providing two alternative abundance indices. If fishing patterns have changed significantly over time (e.g. if vessels now commonly employ more fishers or lines than in previous years), the 'Man Days' index should be a better effort measure than just 'Days at Sea'. Insufficient time was available to explore this in detail, so both alternatives were examined.

Indices were examined separately for the five main gears that capture king mackerel: a-la-vive; fillet (multifilament gill nets); monofilament gill nets; switchering and trolling. These gears together account for over 96% of the king fish catch weights in the trip records database.

Catch rate data are also believed to be available from the ICCAT observer database. Time constraints at the meeting prevented the analysis of these data.

1.8.3.3 Results and discussion

Abundance indices for both of the CPUE indicators show broadly flat trends, with some differences between gear types (see Figure 2 and Figure 3). Catch rates for some gears appear to have increased gradually since the early 1990s even though catches have been at high levels in this time (see Figure 1).

Only three CPUE data points are available for the years prior to 1991, with only the 1963, 1975 and 1985 trip data having been recently computerized from the original paper records. The fillet gear data points for 1975 and 1985 suggest higher abundances than in the 1990s, but the trolling data points for 1963 and 1975 are lower than the more recent points. Entering the other data for the years prior to 1991 would greatly improve the power of the data set.

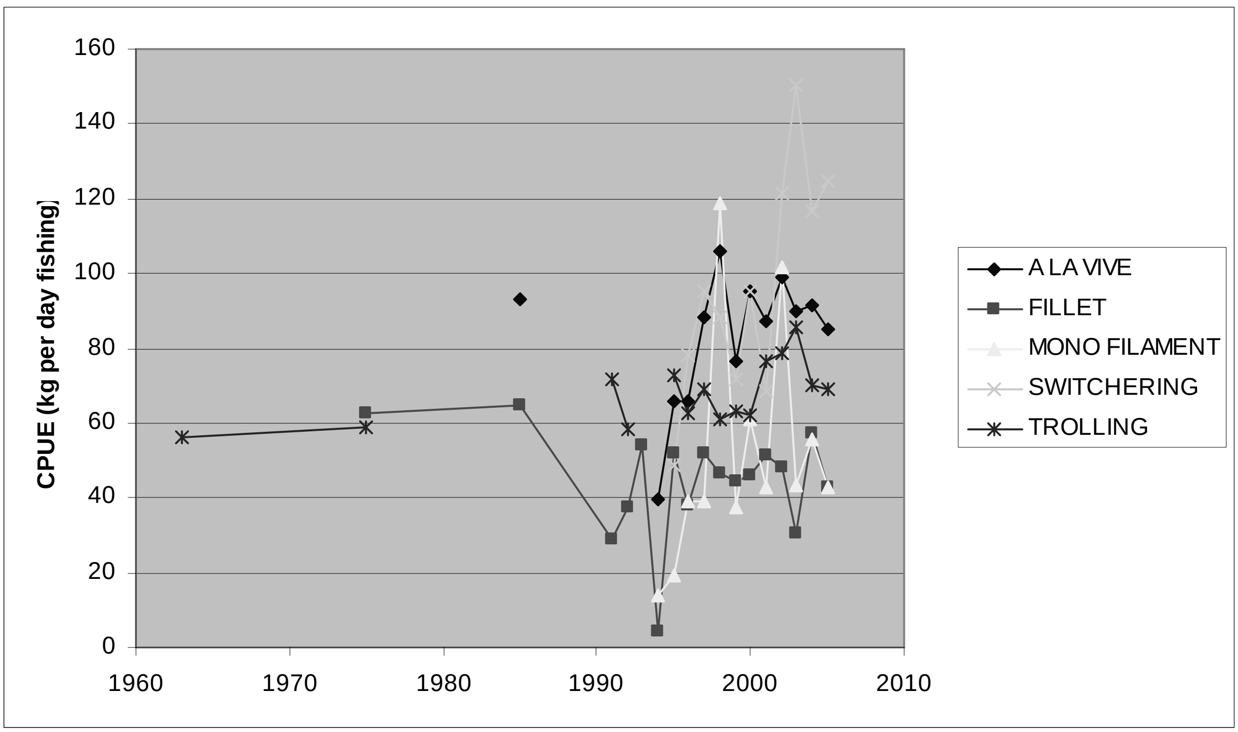


Figure 2. CPUE abundance indices for the five main king fish gear types based on the 'Days at Sea' effort measure for years 1963 to 2005.

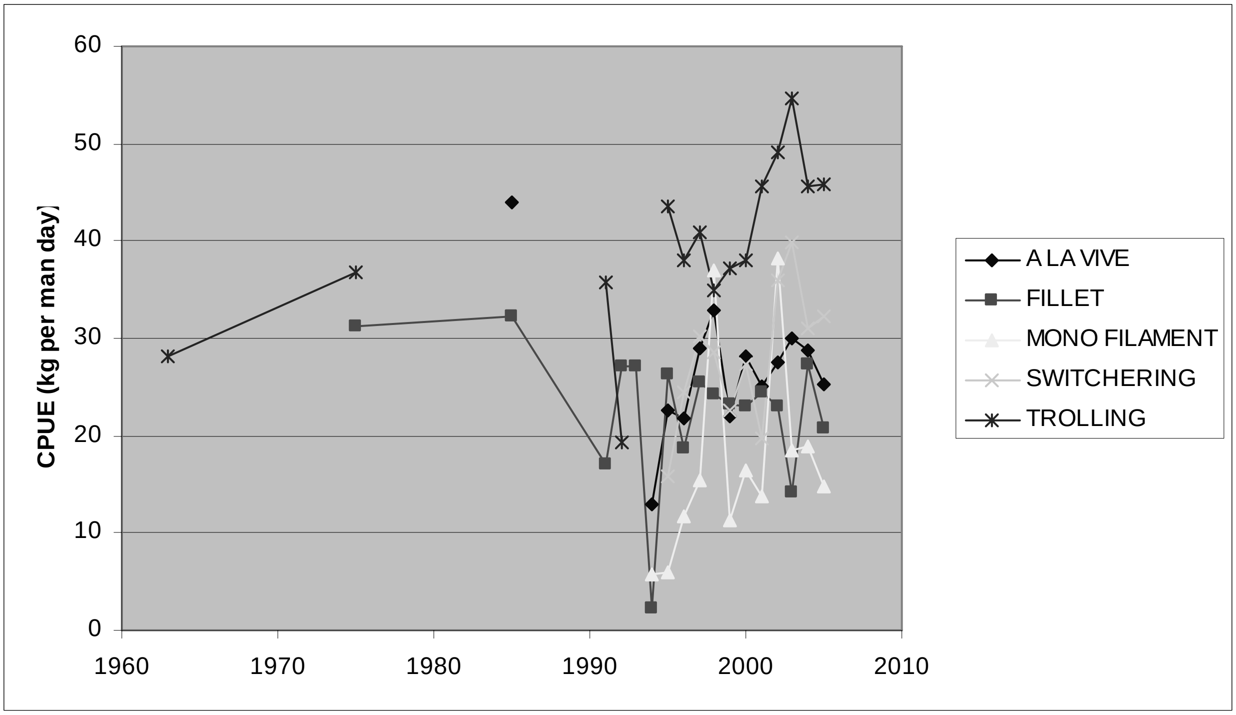


Figure 3. CPUE abundance indices for the five main king fish gear types based on the 'Man-Days at Sea' effort measure for years 1963 to 2005.

1.8.4 Biomass dynamics (production) modeling

1.8.4.1 Objectives

Biomass dynamic (surplus production) modeling was attempted to estimate the changes in stock sizes over time and the maximum sustainable yield (MSY) reference point for the fishery. Such information is estimated from the historical patterns in the annual catch rates or abundance indices (as examined in Section 1.8.3) and the total catches removed from the fishery (as in Section 1.8.2).

1.8.4.2 Data used and methodology

In this analysis, attempts were made to fit the Schaefer production model to each of the two Trinidad CPUE data series (ignoring any differences between gear types), combined with total catches either including or excluding the Brazilian and Venezuelan data sets.

Attempts were made to fit non-equilibrium, observation-error versions of biomass dynamic models both using the CEDA software produced by MRAG (see http://www.fmsp.org.uk/) and using spreadsheet models based on the Excel solver routine (e.g. Punt and Hilborn, 1996; Haddon, 2001). Models were fitted with the biomass at the start of the total catch time series (1950) set at initial estimates of 50%, 75% or 100% of the estimated carrying capacity, *K*.

1.8.4.3 Results and discussion

None of the models attempted gave robust fits to the data. Due to the uncertainties in the data inputs, detailed analysis of the data was postponed until a future meeting.

Future analysis should be postponed until (1) the remaining pre-1991 Trinidadian data have been entered, and (2) the true sizes of the early catches for Venezuela can be verified. Further consideration is also required on the stock structure, particularly on whether to include or exclude the Brazilian catches in the model. Such points may be investigated in the inter-sessional period, or by conducting any future assessment at an ICCAT meeting.

Future analyses may be best conducted using the data from the different gears as separate indices of abundance (as in Figures 2 and 3), rather than as a single aggregate index as attempted this time. This may be accomplished either using the ASPIC model (which allows up to 10 different abundance indices), or by standardizing between the gears using a GLIM analysis to account for changes in fishing patterns over time. To use the data in ASPIC would require the early TT data to be entered in order to divide the total annual catches between the fleets, and thereby associate the abundance indices with their portions of the total catches.

1.8.5 Estimation of growth rates

1.8.5.1 Objective

Growth rates were estimated from length frequency data in order to provide the 'intermediate' parameters required to estimate the mortality rate fishery indicator (see Section 1.8.6), and to run an 'analytical' stock assessment model (as reported in Section 1.8.7).

1.8.5.2 Data used and methodologies

Length frequency data were examined from Trinidad Fisheries Department records, with a total of 4906 fish measured between 1995 and 2004. The sample size in 1995 was small (total n = 65), and no fish were measured in the years 1999 to 2003. The main analysis was thus conducted on data from the period 1996 to 1998. The 2004 data were analyzed to provide updated estimates of mortality rates (see following section), but proved unsuitable for growth modeling.

Fish were measured as fork lengths in cm, and were grouped into 5cm length classes for plotting. Sample sizes were unevenly distributed over time and among the different gear types. Given the small sample sizes and time series of available length data, samples were grouped into quarterly time periods for plotting. To view the growth of fish over time, the length frequencies were plotted against the time of sampling using the 'LFDA' software (http://www.fmsp.org.uk/). Such plots confirmed the anticipated selectivity of the two gill net gears (multifilament and monofilament) and showed that small fish are caught particularly by the beach seine gear (see Attachment 1, Section A1).

Growth rates were estimated both from the 'raw' length frequency data aggregated across all gear types, and from a raised, 'low-selectivity' data set including only the four gear types: a-la-vive, banking, switchering and trolling. All of these gears are varieties of line fishing, which may be expected to show some degree of selectivity due to the hook sizes and baits used. The length frequency data nevertheless showed them to display wider size ranges than the other gill net and seine gears. Samples where gear type was not recorded were excluded from the 'low-selectivity' data set.

The 'low-selectivity' data set was raised by the total catch of each quarter and then aggregated across quarters to give the total weight of fish caught at each length class in each quarter for the overall 1996-98 period. Fifteen percent of the total catches (of these gears) in this period could not be allocated to the data set due to a lack of length frequency samples to raise the catches. Two quarter's samples having only 1-2 fish were also excluded from the raising due to their unbalanced contribution to the overall distribution. The resulting length frequencies contained significantly more large fish than the unraised 'raw' data set, which comprised far more fish from gill nets (see Attachment 1, Section A2).

The 'raw', unraised data was also analyzed to make use of the additional data, on the assumption that selective gears will nevertheless select fish at sizes and time periods as they are available in the fishery, and may thus still show the growth of fish as shifts in length modes over time.

Growth rates were estimated using the FMSP 'Length Frequency Distribution Analysis' (LFDA) software, using the 'SLCA' fitting routine.

1.8.5.3 Results and discussion

Both the 'raw' and the raised 'low-selectivity' data sets proved amenable to fitting the growth parameters, and provided comparable results. However, although both data sets showed clear modes believed to represent age classes, the analysis was unable to reliably determine between a range of alternative growth model fits.

The K-by-$L_{infinity}$ score surface for the 'raw' data set is shown in Figure 4. The graph shows at least three local maxima in the score surface, visible as white shaded areas on the plot representing high scoring combinations of K vs $L_{infinity}$. Each such local maximum represents a combination of K and $L_{infinity}$ parameters that provides a good fit to the data. The actual growth curves corresponding to the low, medium and high $L_{infinity}$ combinations are plotted through the raw data in Figures 5, 6 and 7. The exact position of each local maximum was found using the LFDA maximization routine.

The equivalent score surface for the raised, 'low-selectivity' data set is included as Figure. 8. The growth curves represented by low, medium, high and very high $L_{infinity}$ models are plotted in Figures 9 to 11. With this data set, the real local maximum for the high $L_{infinity}$ model in fact fell outside the response surface shown in Figure 8.

Though the 'full' unraised data set produced curves with reasonable fits to the peaks in the data set, the estimates of $L_{infinity}$ are lower than those for the raised data set for low-selectivity gears. This may reflect the influence of the more selective gill nets on the full data set and the relative absence of large fish, until raised to the true balance of catches from different gears.

Considering literature estimates of parameters, and recognizing the higher validity of the raised, low-selectivity data set over the raw data, the low-$L_{infinity}$ model of Figure 9 and the medium $L_{infinity}$ model of Figure 10 were recognized as the most likely solutions and taken forward to the next stages of analysis. The parameters associated with these models are given as shaded cells in Table 1, for comparison with the other estimates. Although the scores of the 'high' $L_{infinity}$ models are higher than the 'low' and 'medium' solutions (see Table 1), these models were rejected as being far above the values reported in the literature for the species.

Due to the correlation between $L_{infinity}$ and K, it should be noted that the two solutions are essentially the same fit of the data, with both curves going clearly through the main modes in the data. Although essentially similar, the two options provide quite conflicting management advice as shown in the following sections. Further analysis of the data set is thus warranted to see if alternative fitting methods or seasonal growth patterns provide better single solutions. It should be noted that all of the above model fits were done using the non-seasonal SLCA method. A full analysis could investigate the LFDA 'Projmat' and 'Elefan' fitting routines with and without seasonality. Insufficient time was available at the meeting for these further analyses.

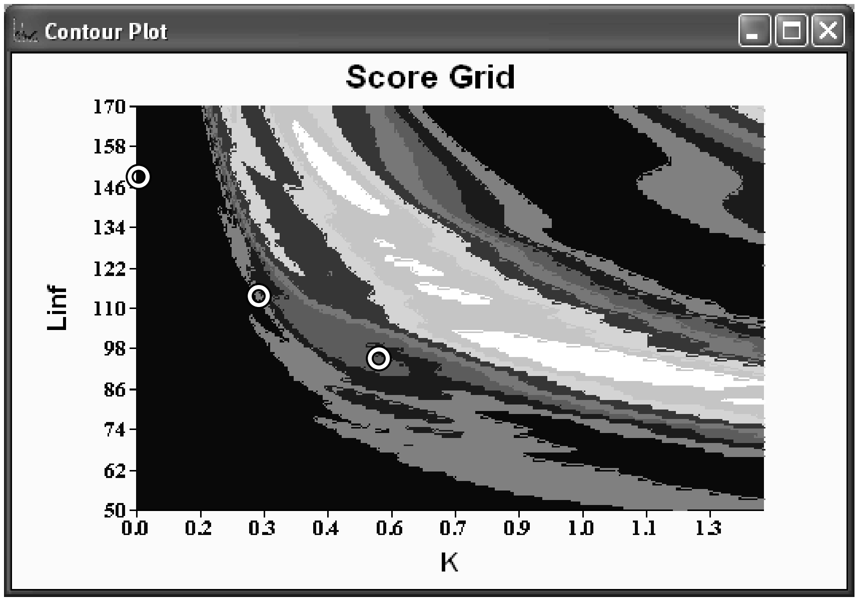


Figure 4. LFDA plot of the scores obtained by different growth curves to the full 1996-98 LF data set. The plot shows contours of the scores obtained by different combinations of the von Bertalanffy growth parameters, K and $L_{infinity}$. Local maxima (white areas implying the highest scores) are evident at low, medium and high $L_{infinity}$ values, as marked by the circle symbols (correlated in pairs with high, medium and low values of K). The curves for each of these fits are plotted through the LF data in the following figures.

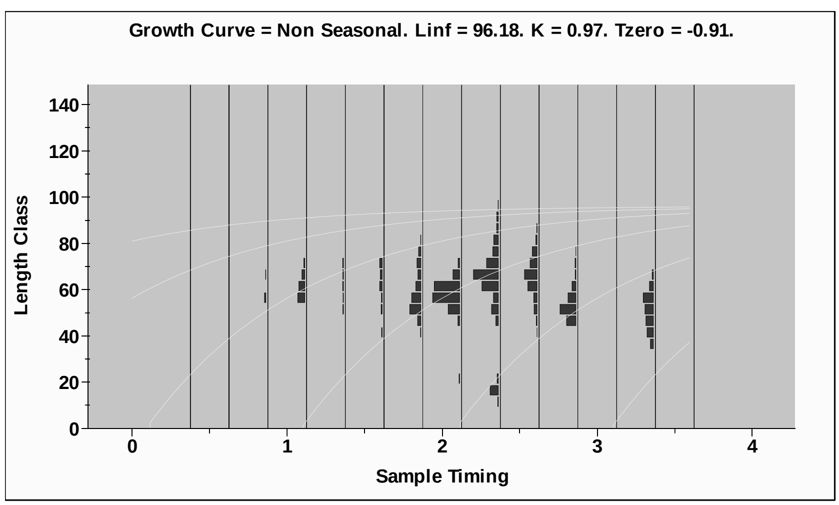


Figure 5. VBGF growth curve fit to the full 1995-98 LF data set for the low $L_{infinity}$ solution. The vertical bars indicate the timings of the quarterly samples between the spring quarter 1995 and the autumn quarter 1998 (i.e. the 0-4 labeling on the x-axis cover the period January 1995 to December 1998). The widest bar represents a maximum frequency in the data set of 209 fish. This fit of the model achieved a score 51, slightly higher than the other local maxima (see below).

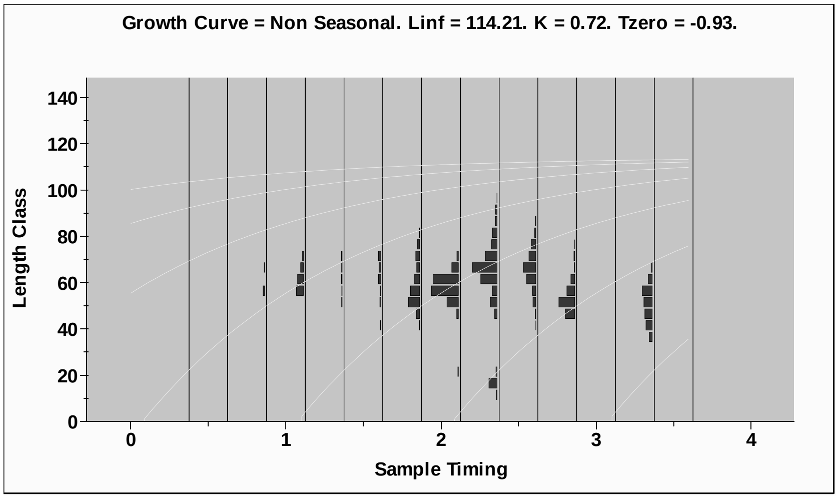


Figure 6. VBGF growth curve fit to the full 1996-98 LF data set for the medium $L_{infinity}$ solution (fitting score = 48).

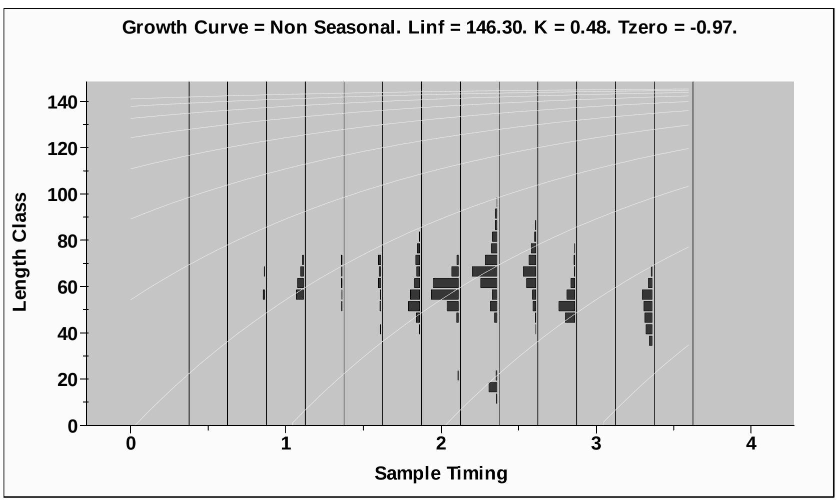


Figure 7. VBGF growth curve fit to the full 1996-98 LF data set for the high $L_{infinity}$ solution (fitting score = 48).

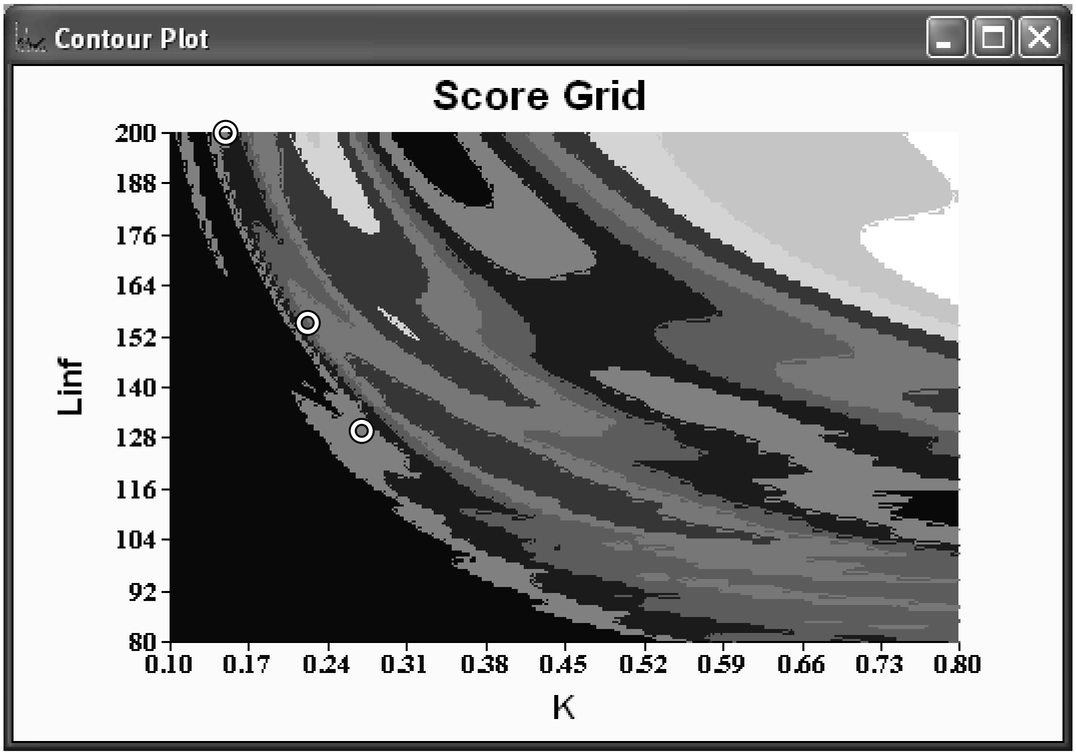


Figure 8. LFDA plot of the scores obtained by different growth curves to the 1996-98 raised, low-selectivity LF data set. The curves for the low, medium and high $L_{infinity}$ solutions, as marked by the circle symbols, are plotted through the LF data in Figure to Figure below. Figure 12 also shows the fit of the 'very high' $L_{infinity}$ solution, which lies above the parameter space, included in the grid and is the real local maxima of the 'high' solution.

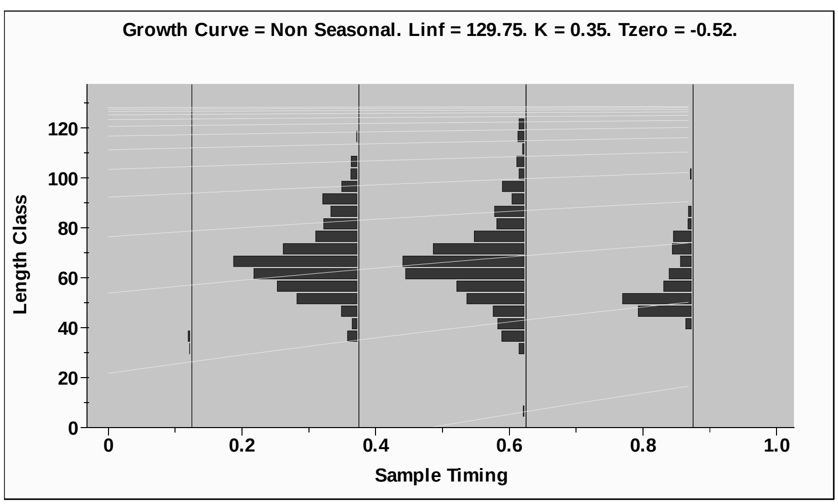


Figure 9. VBGF growth curve fit to the 1996-98 raised, low-selectivity LF data set for the low $L_{infinity}$ solution. This fit of the model achieved a score 379 (compare with other solutions below). As with previous plots, the vertical bars indicate the timings of the quarterly samples (i.e. the 0-1 labeling on this x-axis cover the period January to December for data averaged over the years 1996 to 1998).

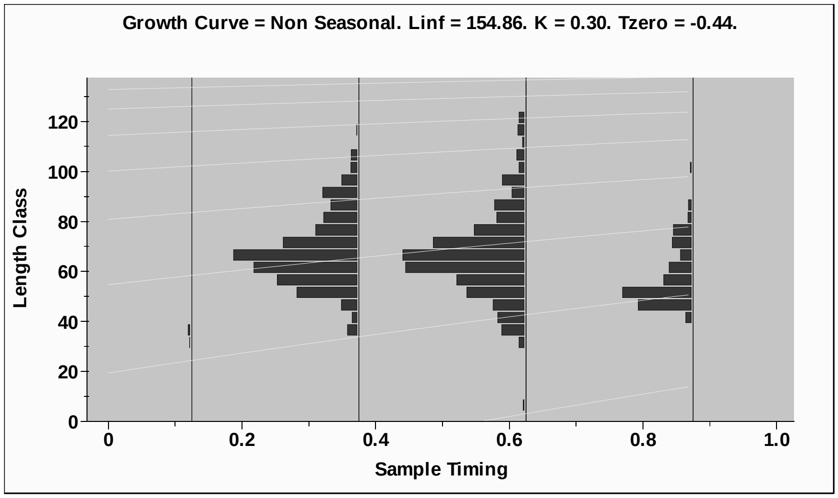


Figure 10. VBGF growth curve fit to the 1996-98 raised, low-selectivity LF data set for the medium $L_{infinity}$ solution (score = 384).

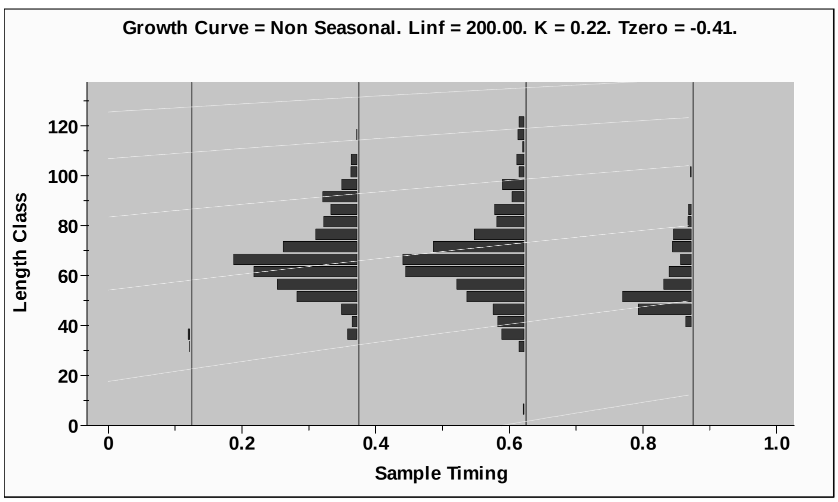


Figure 11. VBGF growth curve fit to the 1996-98 raised, low-selectivity LF data set for the high $L_{infinity}$ solution (score = 442).

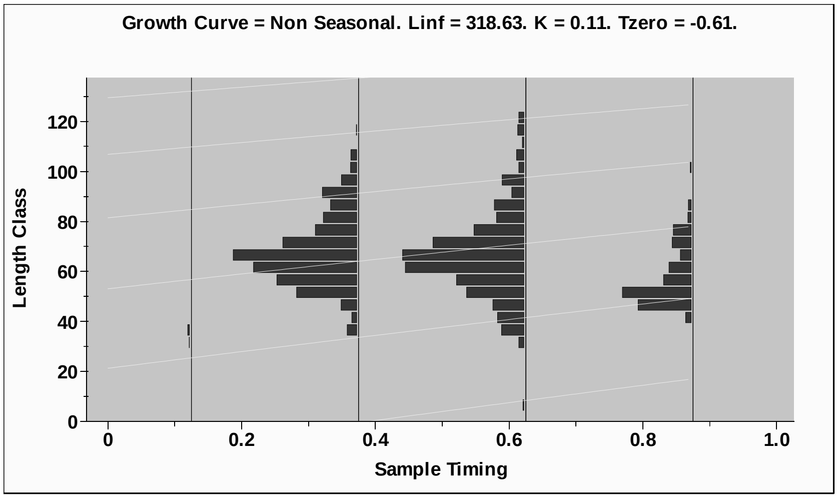


Figure 12. VBGF growth curve fit to the 1996-98 raised, low-selectivity LF data set for the very high $L_{infinity}$ solution (score = 498).

Table 1. Summary of growth parameter model solutions, as fitted for the full 1995-98 LF data set, and the raised, 1996-98 low-selectivity data set. Note that scores may be compared between fits of a single data set, but not between data sets.

Data set	Model fit	$L_{infinity}$	K	t_{zero}	Score
All 1995-98 LF data, not raised	Low L_{inf}	96.00	0.97	-0.91	51
	Medium L_{inf}	114.21	0.72	-0.93	48
	High L_{inf}	146.30	0.48	-0.97	48
1996-98 LF data, low-selectivity gears, raised, to total catches, excluding small samples	Low L_{inf}	129.75	0.35	-0.52	379
	Medium L_{inf}	154.86	0.30	-0.44	384
	High L_{inf}	200.00	0.22	-0.41	442
	Very high L_{inf}	318.63	0.11	-0.61	498

1.8.6 Estimation of mortality rates

1.8.6.1 Objective

Total mortality rates (Z) were also estimated from the length frequency data as indicators of the fishing pressure on the stock, for comparison with the reference points estimated in the 'Yield' analytical' assessment model (see following section). Total mortality rates (Z) are used to estimate the fishing mortality rate indicator (F) by subtracting the natural mortality rate (M).

1.8.6.2 Data used and methodologies

Mortality rates were estimated for the raised 'low-selectivity' length frequency samples combined across years 1996-98 to estimate an average mortality rate for that period, assuming equilibrium within those years. Only the raised, 'low-selectivity' data sets were used to estimate mortality rates to avoid bias due to incorrect weighting of samples in the 'raw' data.

Separate estimates were made of the more recent situation, using the new data collected in 2004. Total length frequency sample sizes per quarter are reported in Table 2. The low sample sizes in 2004 should be noted. The raised length frequencies for 2004 plotted in Figure 13 show less population structure than evident in the larger combined samples of 1996-98. The 2004 mortality rate estimates must thus be considered less reliable than the 1996-98 values, and yet remain as the best available information at this time.

Two alternative fitting methods were used, as implemented in the LFDA software (the ‘length converted catch curve’ and the ‘Beverton-Holt’ methods).

Table 2. Total length frequency sample sizes by quarter and gear type, as used in estimating total mortality rates for the 1996-98 and 2004 years.

Year/s	Gear	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Gear Total
1996-98	A-la-vive	22	729	108	153	1012
	Banking	1	0	74	0	75
	Switchering	0	192	2	0	194
	Trolling	0	144	392	383	919
	Year Total	23	1065	576	536	2200
2004	A-la-vive	0	186	57	3	246
	Switchering	5	103	2	0	110
	Trolling	29	77	25	71	202
	Year Total	34	366	84	74	558

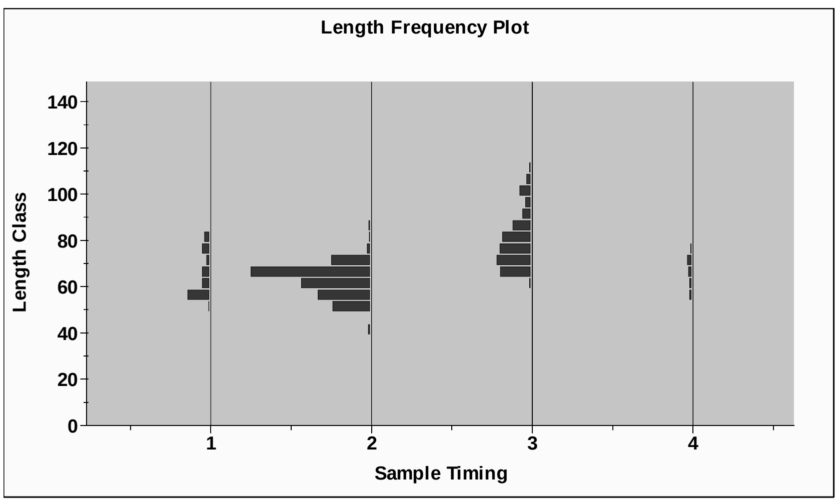


Figure 13. Length frequency data from 2004, low-selectivity gears, raised to the total catches, excluding missing and small samples, as used to estimate total mortality rates. (For LF data used to estimate mortality rates for 1996-98, see

<u>1.8.6.3 Results and discussion</u>

Total mortality rates were estimated in the range 1.13-1.76 for the 1996-98 data set (see Table 3) and at 1.63-2.90 for 2004 (see Table 4). The values quoted are shaded in the tables, and represent the mean values, averaged across the results from each quarter in the year. For the 1996-98 data, the estimate from the first quarter was excluded from the averaging due to its small sample size. The ‘high $L_{infinity}$’ growth curve was also considered and produced even higher estimates of Z.

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 1.

Although the results suggest that mortality rates have increased in recent years, the small sample size in 2004 (n=558) must be borne in mind. It is strongly recommended that new length data are collected during the forthcoming 2006 fishing season to clarify the current position of the fishery. If possible, samples of approximately 200 fish measurements per gear type per month should be collected.

Table 3. Total mortality rate (Z) estimates for each combined quarter's samples (i.e. Q1 to Q4) for the raised, 'low-selectivity' 1996-98 data set, for the different growth model fits, using the length converted catch curve (LCCC) and the Beverton-Holt estimation methods. The reported means give the averages across the four quarters. The shaded means selected for input to the analytical model analysis exclude the low Quarter 1 estimate arising from a small sample size (n = 23, see Table 2).

Model fit	Estimator	Q1	Q2	Q3	Q4	Mean	SE	Mean (excl Q1)	SE (excl Q1)
Low L_{inf}	LCCC	0.88	1.32	0.87	1.19	1.06	0.065	1.13	0.094
	Beverton-Holt	1.01	1.37	1.25	1.52	1.29	0.107	1.38	0.078
Med L_{inf}	LCCC	0.96	1.85	1.26	1.77	1.46	0.122	1.63	0.131
	Beverton-Holt	1.32	1.74	1.60	1.92	1.65	0.128	1.76	0.093
High L_{inf}	LCCC	0.97	2.24	1.52	2.14	1.72	0.170	1.97	0.158
	Beverton-Holt	1.56	2.03	1.87	2.23	1.92	0.141	2.04	0.103

Notes: Lowest fully recruited length (L_c) entered as 65cm for the Bev-Holt estimation method.
SE = Standard error of the mean of the four quarterly estimates.

Table 4. Total mortality rate (Z) estimates for each quarter for the raised, low-selectivity 2004 data set, for the different growth model fits and estimation methods. Z estimates for 2004 are likely to be less reliable than 1996-98 due to the smaller sample sizes.

Model fit	Estimator	Z estimates					
		Q1	Q2	Q3	Q4	Mean	SE
Low L_{inf}	LCCC	1.15	1.66	1.07	2.62	1.63	0.206
	Beverton-Holt	1.96	4.05	1.04	2.32	2.34	0.630
Med L_{inf}	LCCC	1.30	2.33	1.39	3.32	2.09	0.272
	Beverton-Holt	2.45	4.93	1.35	2.87	2.90	0.749
High L_{inf}	LCCC	1.36	2.86	1.63	3.84	2.42	0.330
	Beverton-Holt	2.81	5.54	1.60	3.27	3.31	0.825

1.8.7 Analytical yield per recruit modeling

1.8.7.1 Objective

'Analytical' stock assessment models, also known as 'dynamic pool' or 'yield per recruit' models provide estimates of F-based reference points and are used to estimate the effects of alternative fishery management measures (such as changes in fleet sizes, closed seasons or fish size limits).

1.8.7.2 Data used and methodologies

The model was fitted using the FMSP 'Yield' software which also allows estimates to be entered of the uncertainties in the various model parameters. In addition to entering such parameter uncertainties, separate models were fitted representing the 'low' and 'medium' $L_{infinity}$ growth model fits.

The models were used to estimate the $F_{0.1}$ and $F_{20\%SPR}$ reference points. 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 may be considered an 'efficiency' target for the fishery.

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 (see Gabriel and Mace, 1999). Given the stated objective of maintaining the sustainability of the fishery, the $F_{20\%SPR}$ should not be exceeded. Inputs to the two assessments are given in Table 5. Estimates of fishing mortality for the two periods were averaged across the two fitting methods for comparison with the reference points estimated. Uncertainties in the different parameters were estimated as the coefficients of variation (CVs) among different available local estimates for the parameters. Where no CVs were available, reasonable values were input.

Table 5. Model parameter inputs used in the 'Yield' analytical fishery modeling for the low and medium $L_{infinity}$ growth models. The fishing mortality rates (F = Z – M) given are the means of the two estimates from the LCCC and Beverton-Holt fitting methods (see Table for the full range of fitted estimates). The main analysis was conducted on the 1996-98 growth and mortality rate estimates. The fishing mortality rate (F) indicator estimated (from small sample sizes) for 2004 were also compared with the reference points from the 1996-98 model since no new growth model was fitted.

Year/s	VBGF model fit	$L_{infinity}$	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
2004	Low $L_{infinity}$				1.99		1.48
	Medium $L_{infinity}$				2.50		1.99

Notes: Uncertainty in the VBGF parameters set at CV=0.15, 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).

1.8.7.3 Results and discussion

The median estimates of the reference points for each model fit are given in Table 6, along with the associated levels of the yield per recruit (YPR) and spawning stock biomass per recruit (SSBPR) indicators (expressed as fractions of the unexploited levels). The 5th and 95th percentile estimates of the parameters are also show, representing approximate 90% confidence intervals.

As shown in Figure 14 below, the relationship between the estimated 1996-98 F rates (estimated by subtracting the natural mortality rate, M from Z) and the reference point F values varies depending on the model inputs. In terms of yield per recruit, $F_{96\text{-}98}$ was above the $F_{0.1}$ reference point for both the low and medium $L_{infinity}$ models (as marked on the two left plots in Figure 14), but much further above for the latter model. In other words, if the low $L_{infinity}$ model is correct, the fishery is operating slightly inefficiently, but if the medium $L_{infinity}$ model is correct, the fishery is operating very inefficiently, in terms of using much more fishing effort than necessary to achieve the $F_{0.1}$ catch.

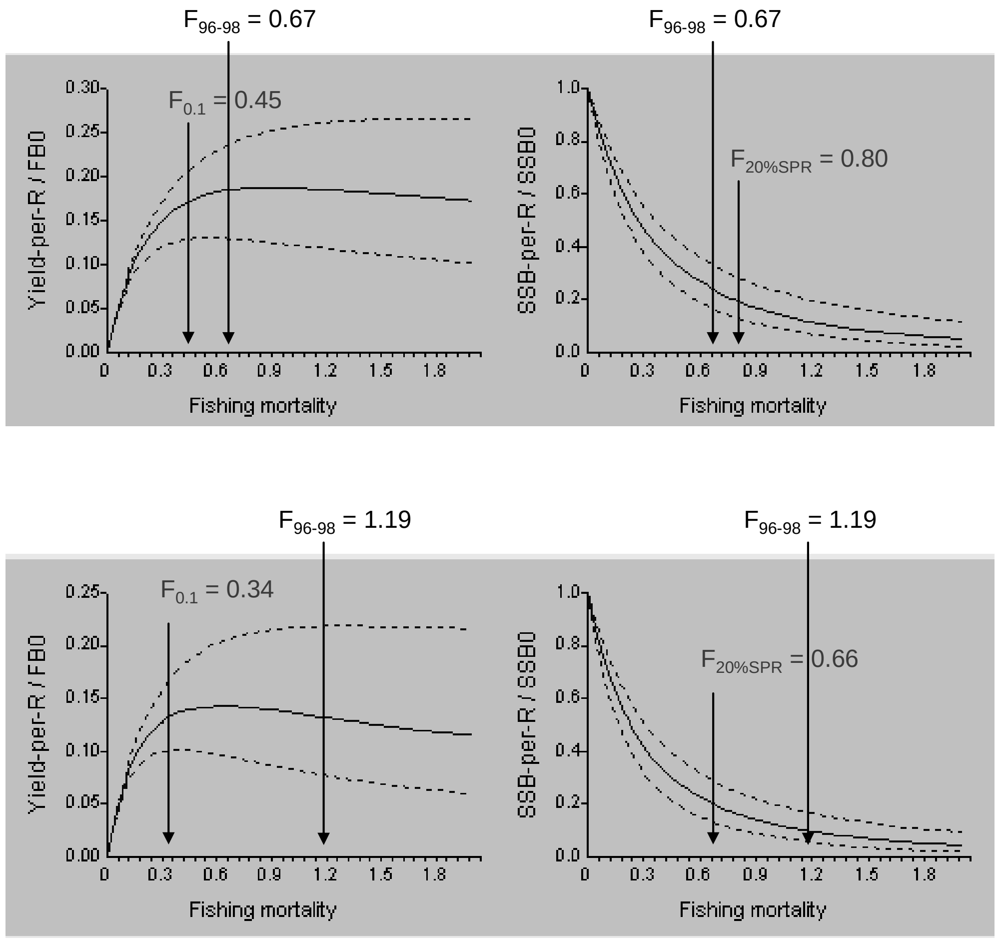
In terms of spawning stock biomass per recruit (plotted in the two right plots of Figure 14, as a proportion of the unfished level), the low $L_{infinity}$ model suggests that the $F_{96\text{-}98}$ was slightly below the $F_{20\%SPR}$ reference point, and hence the fishery should be in 'safe' waters. The medium $L_{infinity}$ model, however, predicts that the $F_{96\text{-}98}$ is almost twice as high as the 20% reference point, and that therefore the fishery is at risk of recruitment failure. Further uncertainties are implied by the dotted 95% confidence intervals included in the plots.

Further analysis is required to improve the understanding of the current stock position relative to the reference points. However, since the medium $L_{infinity}$ model is feasible, and further since the 2004 F estimates are even higher than those reported in Figure 1 for 1996-98 (F_{2004} = 1.48 and 1.99 for the two model fits), there is clearly cause for concern.

Reductions in the fishing mortality rate could be achieved by applying controls to the fishing effort. Such options are reported as feasible for Trinidad and Tobago, but should be applied throughout the unit stock range to be effective. The relative effects on the relative YPR and SSBPR indicators of closed seasons or a fish size limit were also briefly investigated, as reported in Table 7. The analysis predicted that closed seasons of three months (January to March) or six months (October to March), would increase the relative SSBPR from the 10% currently estimated in the medium $L_{infinity}$ model up to 13% and 22% respectively. As an alternative, increasing the size at first capture in the fishery (e.g. by enforcing fish and/or mesh size limits) from the current 50cm up to 60cm would also raise %SSBPR up to 19%. As shown in Table 7, allowing the size limit to decrease down to 30cm would reduce the %SSBPR down to dangerous values in the range 7-9% and should clearly be avoided.

Table 6. Estimated $F_{0.1}$ and $F_{20\%SPR}$ reference points for the low and medium $L_{infinity}$ growth model fits as derived from the 1996-98 length frequency data using the 'Yield' model. The 5^{th} and 95^{th} percentile points indicate approximate 90% confidence interval for the estimates, based on the uncertainty entered for the input parameters. The lower lines in the table give the levels of the YPR and SSBPR indicators (relative to the unexploited fishable biomass per recruit and the unexploited SSBPR respectively) associated with each reference point.

Reference points	Low $L_{infinity}$ fit			Medium $L_{infinity}$ fit		
	5th %ile	Median	95th %ile	5th %ile	Median	95th %ile
$F_{0.1}$	0.33	0.45	0.66	0.26	0.34	0.47
$F_{20\%SPR}$	0.62	0.80	1.11	0.51	0.66	0.86
Levels of indicators at $F_{0.1}$ reference point						
Relative YPR	0.13	0.17	0.24	0.10	0.13	0.17
Relative SSBPR	0.26	0.36	0.40	0.34	0.38	0.40
Levels of indicators at $F_{20\%SPR}$ reference point						
Relative YPR	0.14	0.19	0.25	0.11	0.14	0.19
Relative SSBPR	Set at 0.2					



Low $L_{infinity}$ model
(i.e. higher K & M)

Medium $L_{infinity}$ model
(i.e. lower K & M)

Figure 14. 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 data set estimated using each model fit ($F_{96\text{-}98}$ = 0.67 and 1.19 respectively), 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.

Table 7. Estimated effects on the relative YPR and SSBPR indicators, of introducing 3 month (January-March) or 6 month (October-March) closed seasons, or of changing the average size at first capture from the current ~50cm to 60cm (e.g. by enforcing a mesh size limit), or to 30cm (e.g. if small meshed nets become more common in the fishery). The 2.5 and 97.5 percentile points indicate approximate 95% confidence interval for the estimates, based on the uncertainty entered for the input parameters.

	Management measure	Relative YPR			Relative SSBPR		
		2.5 %ile	Median	97.5 %ile	2.5 %ile	Median	97.5 %ile
Low $L_{infinity}$ growth model fit	Baseline (no change)	0.14	0.18	0.23	0.19	0.24	0.33
	3 month closed season	0.14	0.17	0.22	0.24	0.32	0.42
	6 month closed season	0.13	0.16	0.18	0.37	0.45	0.53
	60cm fish size limit	0.15	0.20	0.28	0.23	0.32	0.49
	30cm fish size limit	0.10	0.14	0.19	0.09	0.16	0.22
Medium $L_{infinity}$	Baseline (no change)	0.09	0.13	0.23	0.06	0.10	0.16
	3 month closed season	0.10	0.14	0.21	0.09	0.13	0.20

growth model fit	6 month closed season	0.10	0.14	0.19	0.15	0.22	0.32
	60cm fish size limit	0.12	0.17	0.25	0.13	0.19	0.37
	30cm fish size limit	0.06	0.09	0.14	0.04	0.07	0.12

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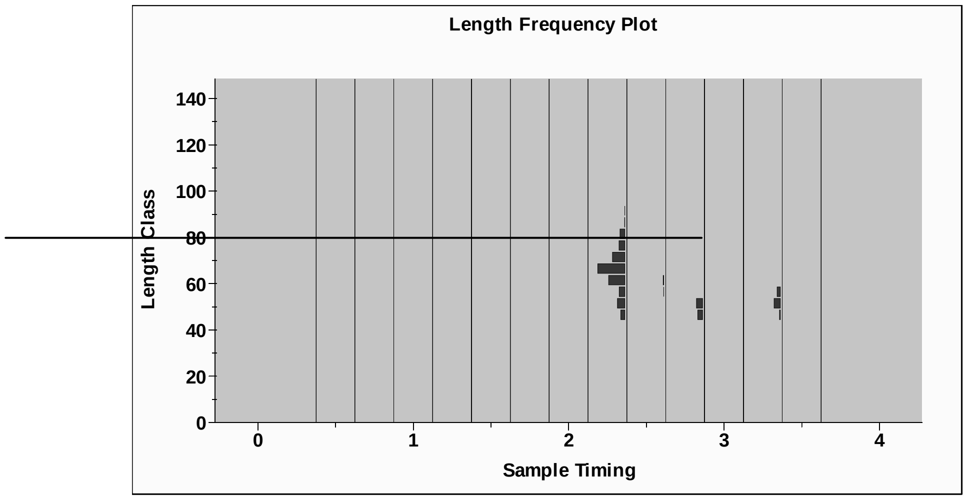
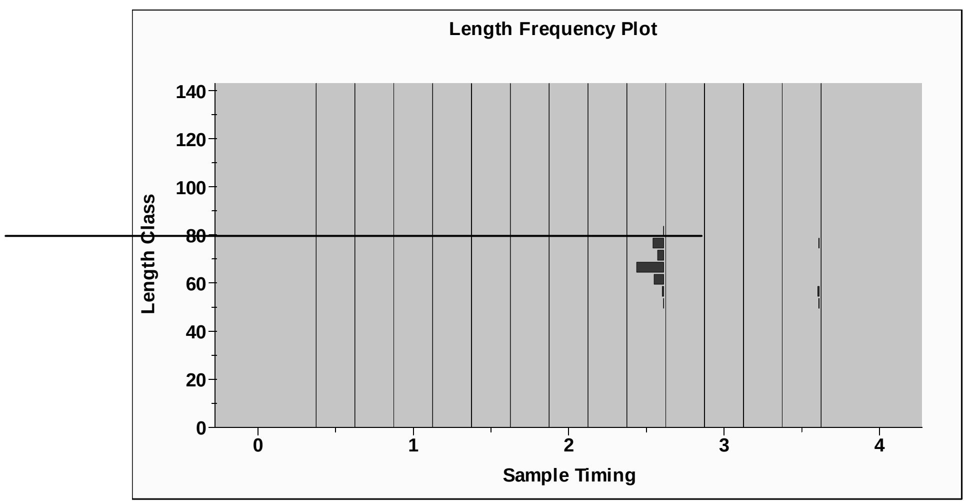
Attachment 1: Data and results appendix

A1. Length frequency plots by quarter and gear type for years 1995 to 1998

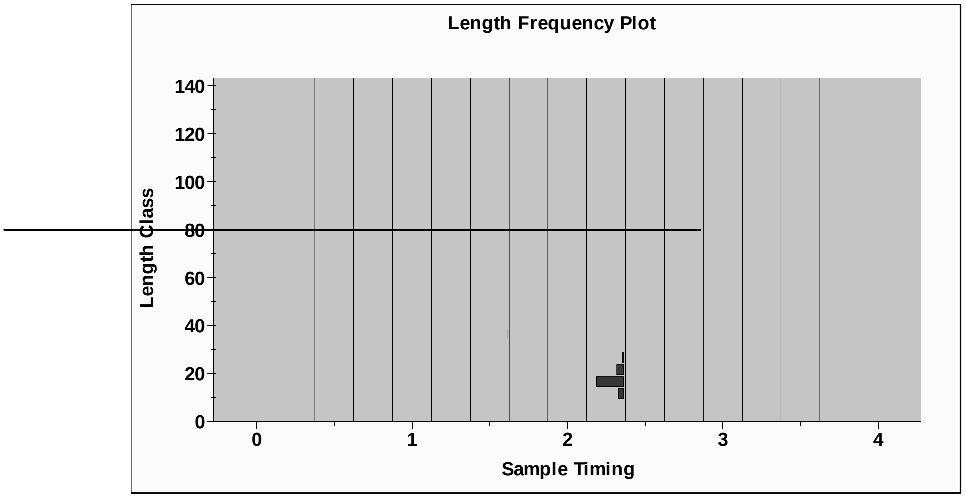
In x-axis of following plots, 0 = 1 Jan 1995, 1 = 1 Jan 1996 etc.
Line at 80cm added to facilitate comparisons
'Maximum frequencies' show the number of fish represented by the widest bar in each plot and should be noted in comparing likely reliability of the different plots.
Plots derived using pivot tables in '<u>Kingfish Length Frequency (w Pivot table).xls</u>' spreadsheet



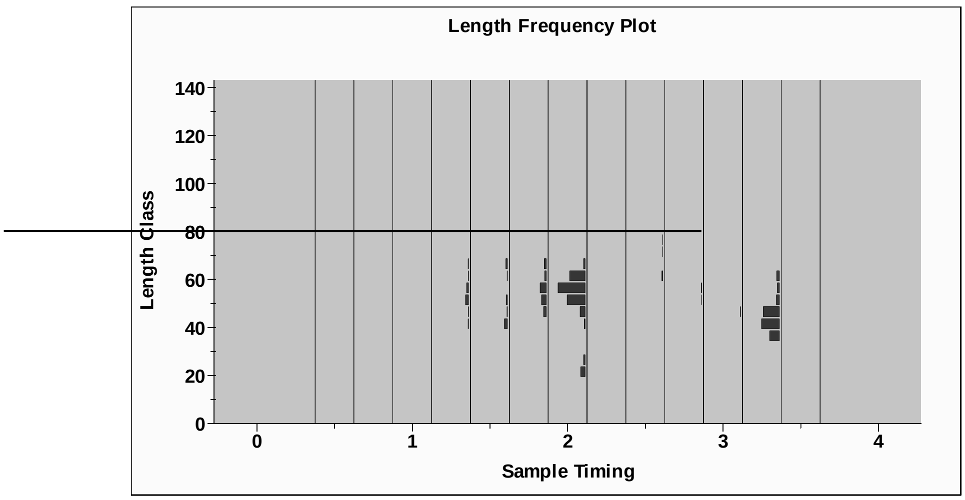
A-la-vive (maximum frequency = 160)



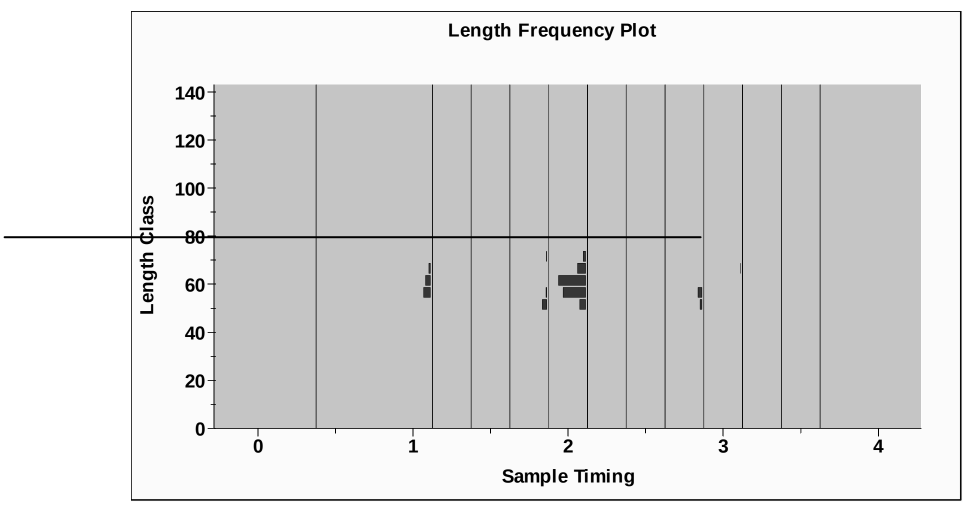
Banking (maximum frequency = 25)



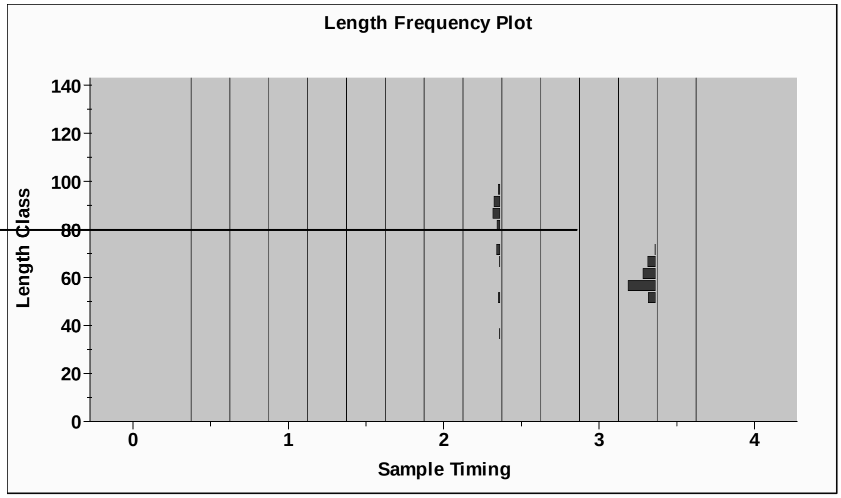
Beach seine (maximum frequency = 74)



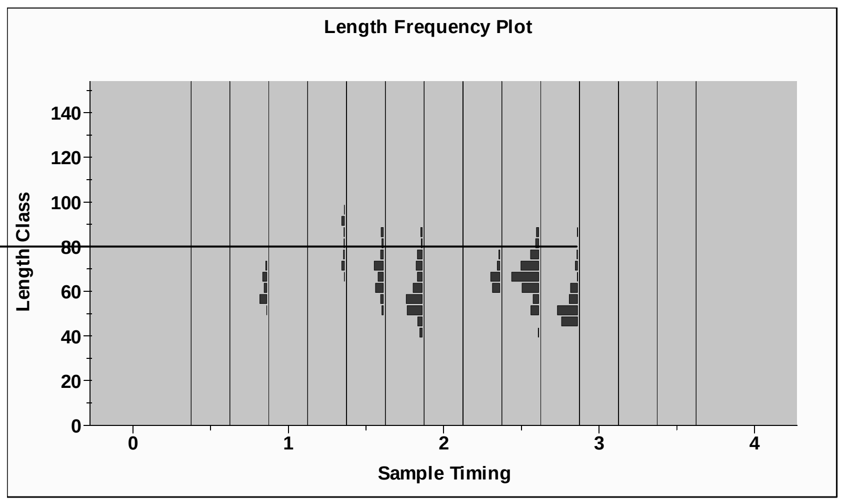
Mono Gillnet (maximum frequency = 84)



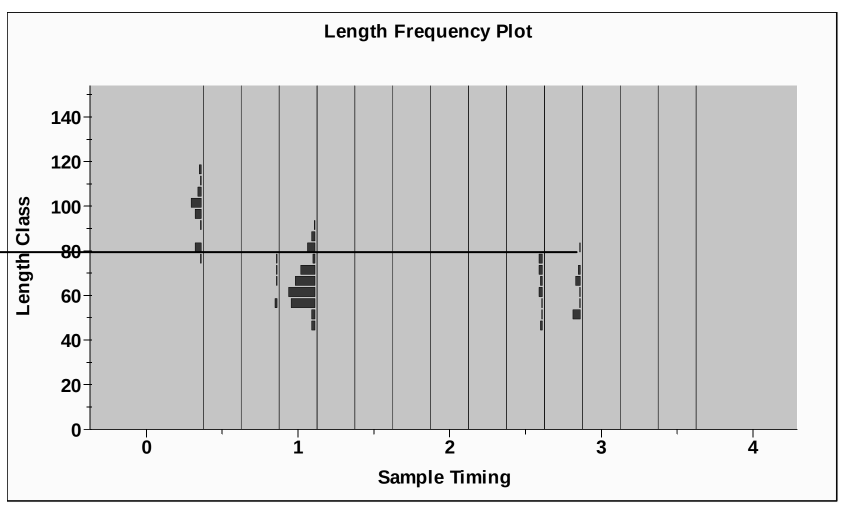
Multifilament Gillnet (maximum frequency = 147)



Switchering (maximum frequency = 49)



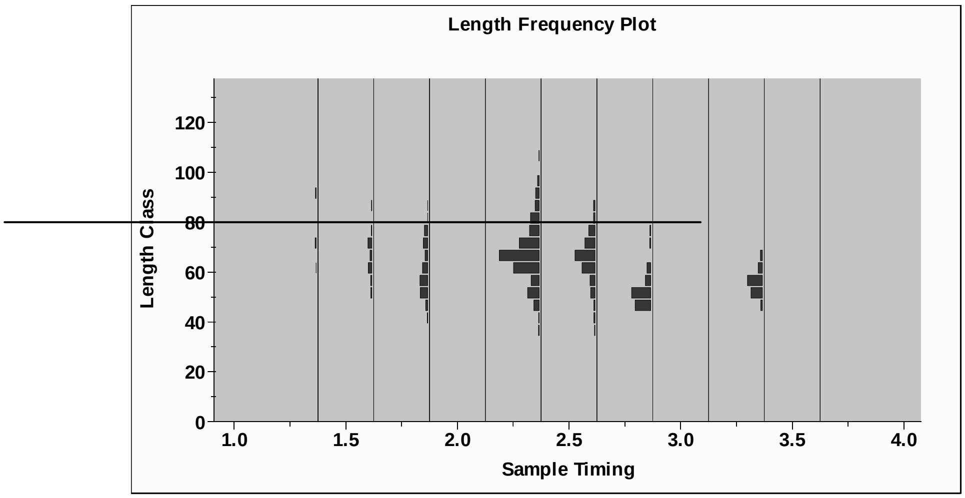
Trolling (maximum frequency = 68)



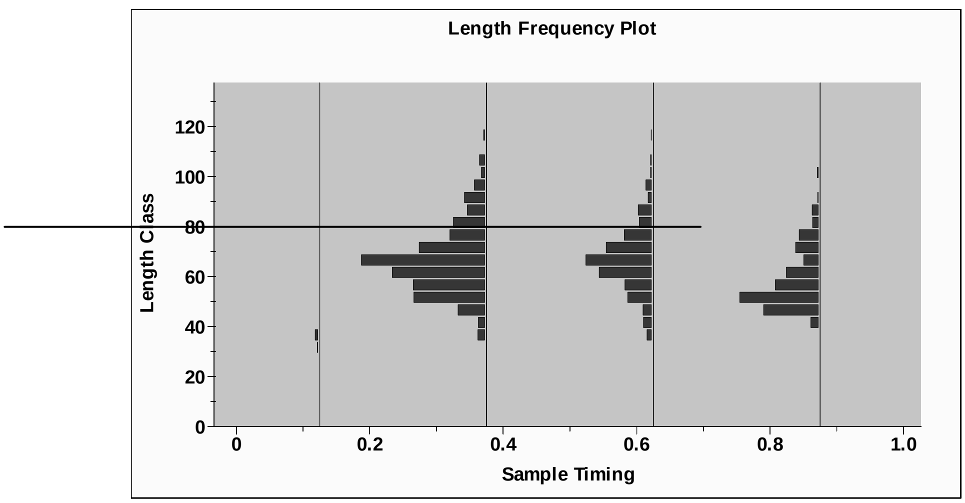
'Other' and 'unknown' gears (maximum frequency = 21)

A2. Raising of 1996-98 LF data for low-selectivity gears

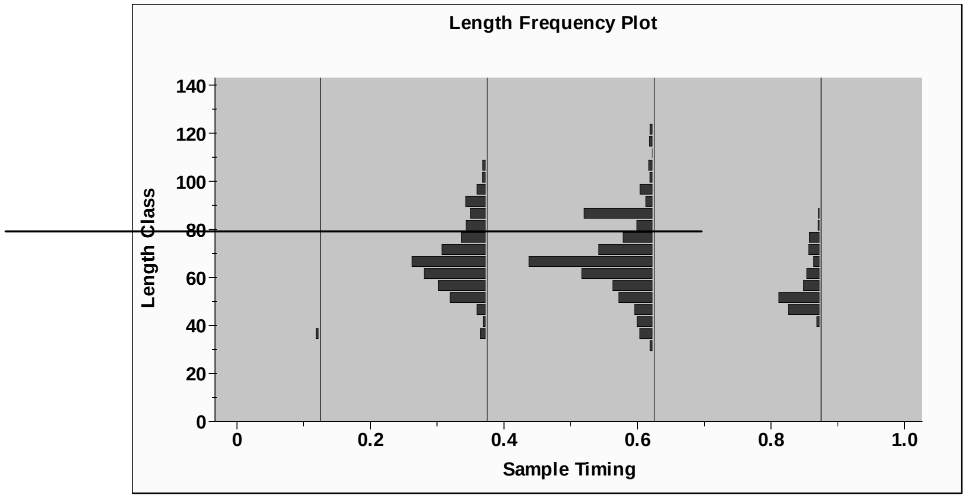
Graphs below show effect of raising factors on the LFs used for analysis, and the effect of excluding the two small samples. Calculations in 'Raised LFs 96-98' page of 'Kingfish Length Frequency (w Pivot table).xls' spreadsheet.



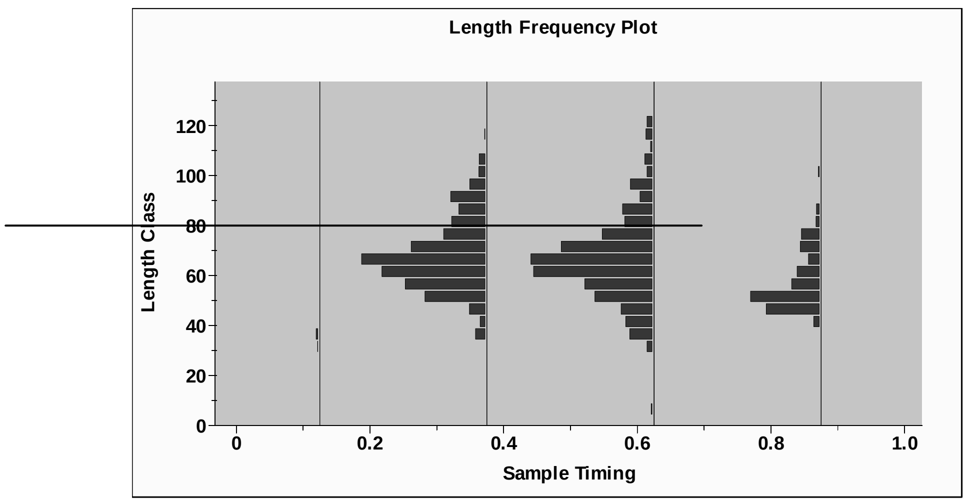
1996-98 Low-selectivity gears combined (a-la-vive, banking, switchering, trolling), separate for each year, not yet raised



1996-98 Low-selectivity gears combined across years, but not yet raised



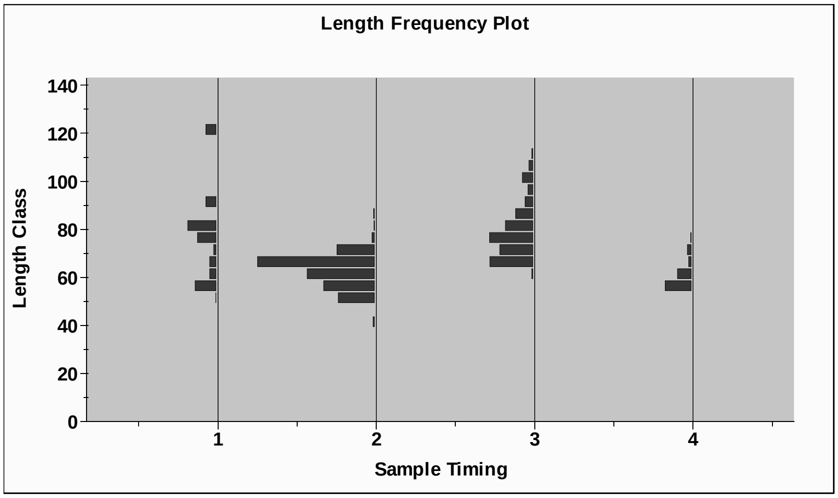
1996-98 Low-selectivity gears combined, raised by total catches in each quarter (15% not possible due to missing samples), but note large effect of small sample (n=2) LF in 3rd quarter



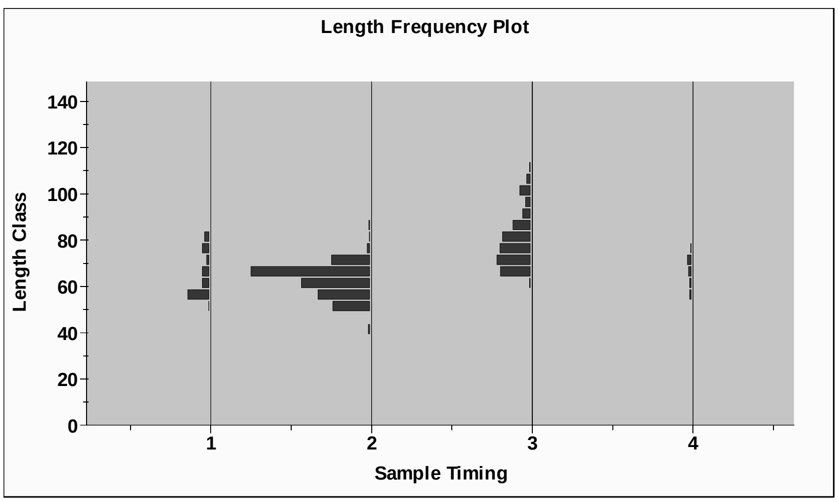
1996-98 Low-selectivity gears combined and raised, excluding small samples

A3. Raising of 2004 LF data for low-selectivity gears

Graphs below show impact of excluding 3 small samples from final 'raised LFs' for 2004. See 'Raised LFs 2004' page of 'Kingfish Length Frequency (w Pivot table).xls' spreadsheet.



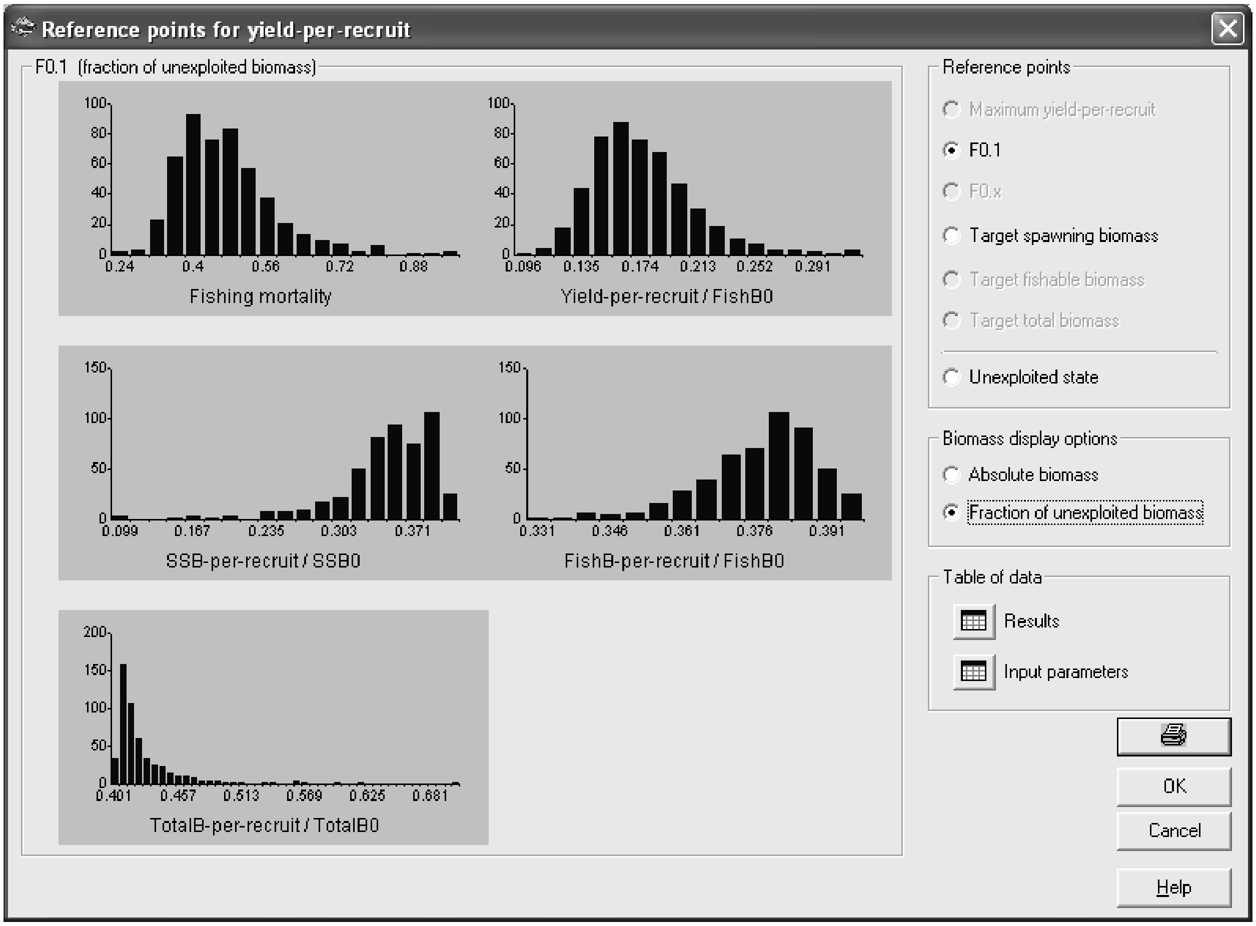
Low-Sel gears, raised LFs, including 3 small samples (n = 2, 3, 5)



Low-Sel gears, raised LFs, excluding 3 small samples (note effect on first sample particularly)

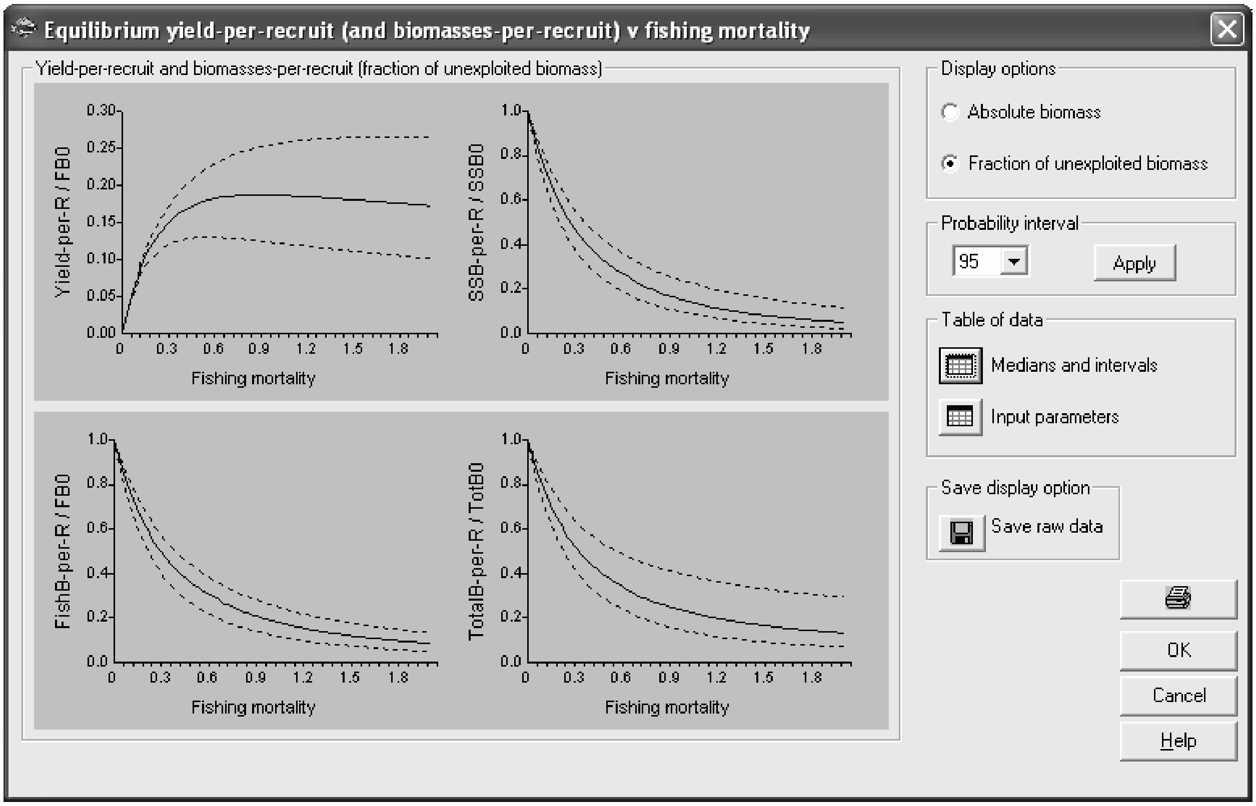
A4. Estimation of reference points in Yield model

Results in Table 6 derived from Yield 'Equilibrium YPR reference points' model outputs as example below, selecting button for 'fraction of unexploited biomass display, based on 500 simulations, with results table pasted into 'Baseline outputs & percentiles.xls' spreadsheet (RefPts page), then sorted to get each percentile point.



A5. Estimation of indicators for alternative management options (Yield model)

Results in Table 7 derived from Yield 'Equilibrium YPR vs F' model outputs as example below, selecting button for 'fraction of unexploited biomass display', based on 500 simulations, with lines for appropriate F values pasted from 'Medians and intervals' table pasted into 'Baseline outputs & percentiles.xls' spreadsheet (Indicators page).



2. Dolphinfish (*Coryphaena hippurus*) fishery

Rapporteurs: Christopher Parker, Josh Sladek Nowlis and Kristin Kleisner, with contributions from Susan Singh-Renton

MANAGEMENT SUMMARY – EASTERN CARIBBEAN

2.1 Policy and objectives
For most of the countries fishing dolphinfish in the eastern Caribbean, the management objectives for dolphinfish specifically, were 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 the dolphinfish to direct future stock assessments and further refine management recommendations for the species.

2.2 Status of stocks
Based on the data available for the present study, mean catch rates (standardized catch per trip) of dolphinfish in the eastern Caribbean have fluctuated between about 50.3 kg/trip and 61.6 kg/trip, with a possible slightly increasing temporal trend overall during the period 1995 to 2004 (Figure 3). It should be noted that the possible increase in CPUE is not considered to reflect any real increase in the abundance of dolphinfish over time. Nonetheless, if there is any real increase the change appears to be very minor. Given no decline in catch rates, catches may be presumed to be sustainable at these levels of harvest. Attempts to estimate stock biomass using a surplus production model proved problematic, and therefore these results were not used to develop management advice at this time.

2.3 Management advice
The assessments conducted at this workshop cannot be considered conclusive enough to predict the long-term sustainability of the fishery at current or increased levels of exploitation. A time series of landings was constructed back to 1950, albeit based on a number of assumptions. A major limiting factor was the lack of adequate measures of abundance through time. Ideally, abundance indices are developed from scientifically designed surveys, which use consistent sampling methods over time. Because surveys of this sort are rare for this region, the alternative is to examine catch per unit effort from various sectors of the fishery. However, these indices may prove misleading, especially if the effort involved is characterized in gross measures such as the number of trips without considering factors that effect changes in the fishing efficiency of each trip which may have taken place during the study period. Fishing efficiency is affected by both readily quantifiable parameters such as the number of hooks used, the time each gear was in the water (soak time) etc. and less quantifiable factors such as improved fisher knowledge in fishing techniques, locating good fishing grounds and even the creation of good fishing areas through the use of moored FADs.

Although adequate data was not available at the time of this meeting, anecdotal information suggests that dolphinfish is being increasingly targeted by pelagic fishers both in the Caribbean, the USA and possibly by extra-regional fishing fleets fishing in the region. 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 fishing the same dolphin stock, management of this fishery must be based on collaborative arrangements between the CARICOM and major non-CARICOM fishing nations in the region including Venezuela in the South to the French Islands of Martinique and Guadeloupe and the US. The suggestion to form such a multinational management body as well as available options, have previously been presented in detail in FAO (2004). Once the mechanisms for collaboration in management are in place, appropriate management measures which consider the trade-offs between meeting individual country needs and stock conservation can be agreed upon for implementation.

It is noteworthy that despite the importance of the dolphinfish fishery to the Caribbean, only six CRFM countries submitted data for inclusion in this assessment. It is further noted that records for dolphinfish were available from the FAO database for only 13 Caribbean nations. Clearly working with such limited databases will continue to be a cause for concern when stock assessments are attempted. All dolphin fishing nations must therefore improve their efforts at capturing and reporting at least national catch data so that they can be adequately included in these stock assessments.

1. The CRFM should continue to monitor catch rate trends at a regional level and coordinate more intensive stock assessments particularly encouraging wider collaboration with non-CRFM nations fishing this resource.
2. However, individual countries must also be encouraged to track the catch rate trends of their own fishery to allow early detection of any changes that may signal stock decline.
3. In the event that catches or catch rates decline, the CRFM should facilitate prompt collaboration among countries to achieve consensus on the appropriate management strategies to be adopted.

2.4 Stock assessment summary

The Working Group initially examined approximately 64,000 trip catch records for five CRFM nations (Barbados, Dominica, Grenada, St. Lucia, St. Vincent) spanning the period 1995 to 2004. Only Barbados and St. Lucia provided trip data series for all years. Dominica and Trinidad submitted summarized data for the period under consideration. However as these data were not disaggregated to the level of individual trips they could not be included in the abundance analyses that were undertaken at this meeting. Following the data preparation process for the analyses, it was necessary to delete a number of records for various reasons (see detailed report) to enhance consistency in data over time, and in the end a total of just over 60,000 records was used.

Changes in annual mean catch per unit effort (trip) were used as indices of abundance for the Eastern Caribbean and Southeastern US dolphinfish fisheries. Generalized Linear Models (GLMs) were applied to each of the datasets to standardize the data with respect to key factors identified (e.g. gear type, season). For the Eastern Caribbean dataset, the standardized annual CPUE estimates appeared to remain fairly constant with a slight positive increase over the ten-year time period examined (1995-2004).

Attempts were also made to apply surplus production models using the standardized CPUE estimates and historic catch records from countries fishing dolphin in the Western Atlantic going as back as far as 1950. A Surplus Production Incorporating Covariance (ASPIC) programme was used for this procedure. However, the models produced unrealistically high estimates of biomass and MSY, suggesting that the data available were not adequate to sufficiently resolve the model.

2.5 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:

2.5.1 Recommendations for the Caribbean Regional Fisheries Mechanism

1. Continue to encourage participation and further collaboration of non-CRFM territories in the Western Central Atlantic (WCA) region e.g., USA, Venezuela and the French territories in future stock assessments. It should be noted that the US did actively participate in this meeting.

2. Review systems (e.g., logbook and/or observer) for recording more refined estimates of fishing effort among countries (e.g., linking catches to gear type; specification of gear configurations; identifying when there is a switch in target species), estimation of total catches from recorded data, and validation of data before submission for consideration in assessments.
3. 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.
4. Encourage and assist countries to develop 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 (CFRAMP) in the early 1990s. This exercise will involve intensive data mining from scientific, historical and administrative documents (both published and gray literature) designed to expand the time series of available data, improve the contrast in the data set and contribute to improved parameter fitting in assessment models.

2.5.2 Individual countries

1. Countries must ensure that appropriate systems are in place to capture, record and report at least representative landings data for dolphinfish.
2. Provide accurate and complete data on total catches (or landings) of dolphinfish 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.
4. 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.
5. 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.
6. 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.

2.6 Special comments

None.

2.7 Policy Summary

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

2.8 Scientific assessments – Eastern Caribbean and United States

2.8.1 Background

2.8.1.1 Biology

The dolphinfish is renowned for its aggressive feeding behaviour, relatively abundant numbers, and its prized status as a game and food fish. The dolphinfish is a highly migratory pelagic species that has been shown to be capable of swimming more than 80 miles in 24 hours (Hammond, 1998). Dolphinfish inhabit tropical and subtropical surface oceanic waters worldwide and are reported in the literature to be bounded in the north and south Atlantic by the 20° Celsius isotherm (Palko et al., 1982) and in the Pacific by the 23° C isotherm (Kraul, 1999). There have also been recent reports of a pole-ward extension of this species in the Pacific in response to continued warming of the oceanic habitat (Norton, 1999). The range for dolphinfish in the western Atlantic has been recorded to be from Nova Scotia (Vladykov and McKenzie, 1935; Tibbo, 1962) to Rio de Janeiro, Brazil (Ribeiro, 1918; Scherbachev, 1973). However, this species is generally considered to be common only from North Carolina throughout the Gulf of Mexico and

Caribbean to the northeastern coast of Brazil, and they are only seasonally abundant at these locations (Oxenford, 1999). Within this noted range, the U.S. longline fleet has reported high dolphinfish CPUE farther north in the Atlantic.

The species is generally considered to be fast growing and short lived (<2 years). It reaches sexual maturity at an early age with dolphinfish in the western central Atlantic reaching first maturity within the first year of life. Dolphinfish exhibit high fecundity. Dolphinfish in the western central Atlantic area may have an extended spawning season peaking in May through June. This species is piscivorous, feeding mainly on scombrids, exocoetids, clupeids, cephalopods, and to a lesser extent species associated with floating material (Oxenford, 1999).

2.8.1.2 Distribution, migration and stock structure

In the context of a stock assessment, the distribution, migration and stock structure of a species define the geographical limits of the management unit. Based on life history and limited genetic data, Oxenford and Hunte (1986) suggested the existence of at least two distinct aggregations of dolphinfish in the western central Atlantic (WCA) region with the ranges of the two possible stocks overlapping in the vicinity of Puerto Rico. Rivera and Appeldoorn (2000) disputed this two stock hypothesis based upon detailed studies of age and growth data on dolphinfish taken in the presumed area of the overlapping ranges near Puerto Rico. Based on a restriction fragment length polymorphism analysis of the ND-1 region of the mitochondrial DNA for dolphinfish samples collected throughout the region, Wingrove (2000) failed to find evidence to support the existence of separate dolphin stocks in the WCA region (Wingrove, 2000). However, a more recent genetic study that also included analysis of microsatellite variation at five polymorphic nuclear loci from dolphinfish samples suggested the existence of at least three genetically distinct populations in the region (an eastern Caribbean, southern Florida (Daytona Beach south west to the Gulf of Mexico) and a Carolina/Bermuda stock) (Chapman *et al*., unpublished).

2.8.1.3 The fisheries

2.8.1.3.1 Eastern Caribbean

Dolphinfish is ranked among the top seven oceanic pelagic finfish species landed in the WCA region (Wingrove, 2000) and, in terms of weight and revenue, dolphinfish is considered the most important large pelagic fish landed by commercial fishers in the eastern Caribbean (Oxenford and Hunte, 1986). The fish is taken with a variety of commercial hook and line gear including single hook lines both deployed passively as lurklines (handlines) and actively as trolling lines, as well as vertical and surface longlines. Recreational fishers, primarily using rod and reel gear, also target the fish. As dolphinfish is a major predator of flyingfish the two species are often taken on the same fishing trips. The fish are also known to aggregate around floating objects and as such are often taken around FADs.

Dolphinfish fall within the fishing ranges of nearly every type of marine fishing vessel used in the eastern Caribbean. Caribbean fishing vessels range from small open boats and fibreglass pirogues, with outboard engines, to the larger inboard diesel-powered day launches in Barbados and pelagic iceboats of both Barbados and Tobago. Since the mid-1980s, several islands of the eastern Caribbean have expanded their offshore fisheries for large pelagic species utilizing longlines. Larger pirogues and decked vessels using mechanized mid-water and surface-set longlines with 3 to 10 miles of line and 100 to 500 hooks are employed (George *et al.*, 2001). The fish is only caught incidentally by longline vessels, which mainly target the large tunas. George and coworkers (2001) state that an average trip length of pirogues and dayboats is about 8 to 12 hours, inclusive of travel and search time. Average trip lengths for iceboats range between 4 days (Tobago) and 7 days (Barbados), while longliners may stay out at sea for several days. See Parker (2001) and Parker *et al*. (2001) for more details of the dolphinfish fishery.

2.8.1.3.2 United States

In recent years, landings of dolphinfish from the Atlantic, Caribbean and Gulf of Mexico waters have risen rapidly. In the U.S., recreational landings have increased gradually from about 4 million pounds annually to about 10-14 million pounds, whereas commercial landings have increased dramatically, with recent landings varying between approximately 600,000 and 1.4 million pounds (Figure 1). Historically, recreational fisheries have caught the majority of dolphinfish in U.S. waters (roughly 87%), and it is not uncommon for sport fishermen to bring in buckets of small dolphinfish, or schoolies as they are commonly called, when the larger bulls and cows are not migrating through the area (Hammond, pers. comm). There are now ten million saltwater recreational anglers in the U.S., with the sport growing as much as 20 percent in the last ten years. This is compounded by the fact that dolphinfish catch by recreational anglers was unregulated until 2004, when a bag limit was introduced.

2.8.1.4 Fisheries Management

Dolphinfish fisheries have been mostly unmanaged until recently. The 1994 FAO document on the management of highly migratory species notes that *Coryphaena hippurus* is included in Annex I of the 1982 Convention on the Law of the Sea, which lists highly migratory pelagic species (FAO, 1994). In spite of this acknowledgement, the International Commission for the Conservation of Atlantic Tunas (ICCAT), which manages highly migratory species, does not specifically take responsibility for the management of Atlantic dolphinfish. The Inter-American Tropical Tuna Commission (IATTC) has recently established regulations in the Pacific that require the release of live dolphinfish that are caught in purse seines (IATTC, 2005). They have also begun to identify areas of high dolphinfish bycatch in order to protect artisanal fisheries that are targeting dolphinfish. The two North Atlantic Fisheries Commissions: the Northeast Atlantic Fishery Council (NEAFC) which is advised by the International Council for the Exploration of the Sea (ICES), and the Northwest Atlantic Fisheries Organization (NAFO) do not include dolphinfish in their lists of managed species because they do not regulate any highly migratory species as defined by Annex I of the 1982 Convention on the Law of the Sea. The two FAO commissions, the Western Central Atlantic Fisheries Commission (WECAFC) and the Commission for the Eastern Central Atlantic Fisheries (CECAF), do include dolphinfish as a species of interest, but neither of these commissions deals with the actual management of fisheries as they were established by FAO as advisory bodies to FAO member countries. They can set guidelines, but cannot enforce regulations.

The greatest regulation of dolphinfish in the western Atlantic comes from the recent approval of the Fishery Management Plan for Dolphin and Wahoo in the Atlantic Region by the U.S. Secretary of Commerce. The management plan, developed by the South Atlantic Fisheries Council in conjunction with the Mid-Atlantic and New-England Fisheries Councils, sets limits on catches of dolphin and wahoo for commercial and recreational fishermen in federal waters along the entire Atlantic coast. The management plan also establishes a framework for long-term management of both dolphinfish and wahoo. The U.S. Dolphin/Wahoo Fishery Management Plan was approved in December 2003 and the final rule implementing the regulations for Federal waters became effective on May 27, 2004. The suite of regulations was implemented in three tranches in July, September and November 2004. Under these regulations, by December 2004, the U.S. dolphinfish fishery was subject to: gear restrictions (only hook and line and spearfishing gear may be used and longline gear not to be used in areas where use of that gear is prohibited for highly migratory species); regulated access (owners, dealers and operators of charter boats, headboats and commercial vessels must have permits and may be required to submit reports on their activities); compliance with sea turtle protection measures; catch regulation (catches are limited to 500 lbs of wahoo per trip and 200 lbs of dolphin and wahoo combined for commercial vessels fishing North of 39º N latitude without a Federal commercial vessel permit).

In response to the observed increases in dolphin catches in recent years, the Florida Fish and Wildlife Conservation Commission instituted new rules and limits for dolphinfish in early 2005 and emphasized the need for management of this species. These concerns have been raised in spite of the fact that dolphinfish are known to be very fast growing, and to mature early. These attributes are most likely an adaptive response of this fish to survive in a highly predatory environment. However, it is probably an unwise assumption to think that humans are unable to adversely affect this species when fishing pressure is increasing each year. It is hypothesized that these levels of exploitation could result in localized depletion of stocks and a shift in the historical levels of catch between commercial and recreational fishers.

There are no active management regulations specifically for dolphinfish in any of the eastern Caribbean countries. The need to manage this species at the regional level appears to be generally well accepted. Indeed, the formation of a multinational management body for dolphinfish featured prominently in a recent FAO sponsored study on management options for the large pelagic fisheries of the eastern Caribbean (FAO, 2004). However, these regional management arrangements are yet to be finalized.

2.8.2 Objective

The overall objective of these analyses was to ascertain the current status of the dolphinfish stock or stocks that exist in the eastern Caribbean area and to advise on the future management of dolphinfish fisheries in the region. Standardized catch rates (CPUE) were examined to provide an index of the abundance of the fish stocks in recent years. Data on fish abundance and total catches were used in 'surplus production' modeling to estimate current stock sizes and maximum sustainable yield.

2.8.3 Southern Stock/Eastern Caribbean assessments

Given the debate over the stock structure of dolphinfish in the WCA region, it was decided to run three surplus production models based on different stock structure scenarios (see Figure 1). The first two assumed separate Southern and Northern stocks and modeled them independently, while the third assumed a single stock for the entire WCA region. Therefore, for the presumed separate Southern/Eastern Caribbean model, only the historic catch rates and the CPUE estimates (described earlier in this report) for the Eastern Caribbean were utilized. For the separate Northern/U.S. stock scenario, the historic U.S. catch time series was used along with three U.S. CPUE indices of abundance derived from (1) commercial landings and the Pelagic Observer Programme (POP) from the longline fleet, (2) the Marine Recreational Fishing Statistical Survey and (3) U.S. headboat data. The Southern/Eastern Caribbean stock model is discussed here.

2.8.3.1 Method/models/data

2.8.3.1.1 Data preparation

Data came in two forms: landings data (removals per year) and catch rates (catch per unit effort). The FAO database extending as far back as 1950 was used as the basic source for landings of dolphinfish in the western central Atlantic region. There were however many gaps in the database, especially for most countries in the years prior to the 1980s. The historic catch database was augmented by including the reconstructed dolphinfish catch data produced by Mohammed (2003, and articles with colleagues following immediately after) for St. Vincent, Grenada and St. Lucia. A regional reference extrapolation method was then used to fill in gaps in the time series using the landings data from those countries with records from 1950. These processes produced a historic catch series for the western central Atlantic region from 1950 to the chosen cut-off year of 2004 (Figure 2).

For catch rates, the initial combined data set covered the period 1994 and 2005. However, the reporting time periods differed among reporting countries. As only two countries provided data for 1994 it was decided to start the time series from 1995. Similarly as only two countries (Barbados and St. Lucia) provided data for 2005 and the data set from Barbados was not complete from that year, it was decided to end the time series at 2004. The working group was then left to examine approximately 60,000 fish trip catch records for five CRFM nations (Barbados, Dominica, Grenada, St. Lucia, St. Vincent) spanning the period 1995 to 2004 (Table 1). All these records were screened and those records lacking crucial information such as the date of the landings or catch weights were removed along with obviously incorrect records. It was decided to use whole weight in kilograms as the standard measure of catch weight. Therefore, weights reported as gutted weight (Barbados, Grenada, St. Vincent and St. Lucia) were converted to whole weight using a multiplier of 1.127. Weights reported in lbs were then converted to kilograms.

Landings were reported for a number of gear types including a selection of highly unlikely gears for this species (e.g. fish pots, speargun, gillnet). The highest numbers of landing records were reported for hand lines, troll lines and long lines. These three gear types were therefore considered the likely most important for the fishery and all other records of landings by other gears were excluded from the dataset. Longlines were listed under the codes for surface longlines (SLIN), bottom longline (BLIN) or simply longlines (LLIN). Grenada provided catch records for longliners, however these records were for only one year and thus too few and sporadic to be included in the analysis. St. Vincent also provided data on pirogues using longlines, however these data were also too few and sporadic to be included. Although some islands reported catches separately for troll and handlines it was not possible to estimate the relative proportions taken by the respective gear types due to the multi-gear nature of the fishery explained in Section 2.8.1.3.1. As such the data from the two gear types were combined under the simple designation of "handline" for the analyses.

2.8.3.1.2 Catch rate standardization

A conventional Generalized Linear Model (GLM) approach was used to standardize the natural log transformed eastern Caribbean catch rate (CPUE) data for elucidating inter-annual trends over the period studied (1995-2004). The data were grouped into the following factor groupings to make the model as simple and balanced as possible in terms of numbers of observations (see Table 2) across the time series and still adequately treat what were considered key influencing factors. Two fishing seasons were identified, with the "High season" describing the monthly period when dolphin catches were traditionally highest (February to May, inclusive) and the "Low season" describing the monthly period when catches were comparably lowest (June to January, inclusive). In terms of fishing power and techniques it was deemed appropriate to group vessels along the lines of eastern Caribbean (Dominica, Grenada, St. Lucia and St. Vincent) pirogue; Barbados moses, Barbados day boat, Barbados iceboat and Barbados longliner.
In most cases, information such as the number of gears used, soak times and days fished were not provided by the reporting countries. Therefore, it was only possible to use catch per trip as a crude index of catch per unit effort. Differences in the catches per trip between such vessels thus include any differences due to the trip lengths usually taken by each vessel category (usually one day for pirogues, moses and dayboats, and multiple days for ice boats and long liners).

A stepwise GLM procedure was run (PROC GENMOD, SAS Institute Inc., Version 9.0º) to select the significant factors and interactions for inclusion in the model based on 5% deviance reduction. The final GLM model was run using the GLM routine of the SPSS 10º statistics package.

2.8.3.1.3 Surplus production modeling

Surplus production models were fitted to the data using the estimated historic landings data series and the standardized CPUE abundance indices. A Surplus Production Incorporating Covariance (ASPIC) programme was used for these procedures (Prager, 1994).

2.8.3.2. Results

2.8.3.2.1 Catch rates

The statistics of the stepwise exploratory GLM analysis are presented in Table 3. All factors and interactions were found to have a significant effect on the GLM model. However, none of the factor interactions (i.e. year*season, season*stategear and year*stategear) improved the fit of the model by more than 5%. Therefore, only the fixed factors (i.e. year, season, stategear) were included in the final model. The statistics of the final full factorial model GLM used are presented in Table 4, and normalized and standardized catch rates are presented in Table 5.

An increasing trend is quite noticeable in the nominal (non-standardized) mean annual CPUE values over the ten-year study period (1995-2004) (Figure 3). However, this increasing trend all but completely disappeared after standardization by the GLM procedure (Figure 4). From these data, it may be concluded that dolphinfish catch rates have remained very level over the ten-year study period.

2.8.3.2.2 Surplus production model

The runs in ASPIC illustrated that the available data were inadequate to make any strong conclusions about stock status. When the model attempted to estimate three production parameters (starting population size, maximum sustainable yield (MSY), and carrying capacity), the model could not find a consistent maximum and all results indicated the population had begun at low levels and was now close to virgin conditions. When initial population size was fixed at a range of reasonable values (0.5 to 0.8 of carrying capacity), the stock was assumed to be even closer to virgin conditions today. These results suggested that the model was not finding useful information in the available data.

2.8.4 Northern Stock/United States assessments (Rapporteurs: Josh Sladek Nowlis and Kristin Kleisner)

The northern/U.S. stock of dolphinfish has received earlier attention using techniques similar to those described below (Prager, 2000). This model found that the dolphinfish stock was in healthy condition, although with great uncertainty surrounding this conclusion due to uncertain data inputs, especially the abundance index. The current effort benefited from an observer-based abundance index that was standardized for a number of oceanographic variables.

2.8.4.1 Method/models/data

U.S. landings were compiled from commercial and recreational sectors (Table 1, Figure 5). Though recreational estimates only go back to the early 1980s, earlier catches were estimated using the early ratio of recreational to commercial catches in the U.S. and applying that ratio to the observed commercial catches back to 1950. Commercial landings from the U.S. were added to estimates from northern Caribbean countries.

The Working Group initially examined approximately 5979 trips from the U.S. commercial longline observer programme database spanning the period 1992 to 2003. These data provided the most comprehensive level of catch rate data due to the extensive spatial coordinates for the beginning and ending of each set and haul on a longline trip, and the detailed effort data in terms of soak times and number of hooks per basket. Additionally, the U.S. commercial data had environmental data (SST, distance from nearest SST front, depth of hook, and bottom depth) associated with the average coordinate for each set from which CPUEs were caluclated. This is important because there are several key oceanographic features in the western Atlantic and Gulf of Mexico that may influence the movement of dolphinfish. It is well known that many fish species are associated with frontal boundaries in the ocean. These areas are prime locations for fish because of the tendency for prey to be aggregated by dominant current regimes. In the main fishing areas of the U.S. and eastern Caribbean fleets, there are some major features that are likely to have an influence on the CPUEs of dolphinfish. One major strength of the U.S. pelagic longline observer database is the ability to link satellite derived environmental variables with individual CPUE records.

Changes in annual mean catch per unit effort (kg of dolphin per unit effort, hooks*soak time) were used as indices of abundance for the U.S. dolphinfish fisheries. Generalized Linear Models (GLMs) were applied to each of the datasets to standardize the data with respect to key factors identified (e.g. year, quarter, area, SST, distance from nearest front, depth of hook, and bottom depth). For the U.S. commercial dataset, the standardized annual CPUE estimates appeared to remain fairly constant over the 11 year time series.

A Generalized Linear Mixed Model (GLMM) approach was used to estimate relative indices of abundance for the dolphinfish fishery of the United States Pelagic Longline Observer Programme (U.S. PLOP). With this model, two different methods were used to assess the characteristics of the data: 1) a binomial model was used to describe the positive dolphinfish CPUE observations, and 2) a Delta-Lognormal model, which combines the proportion of positive trips (trips that land dolphinfish). These models were combined to create a single index of abundance.

The influence of the following factors on the relative abundance was investigated: year, quarter, area, target species, SST, distance from nearest front, depth of hooks, and bottom depth. Quarter was defined as: Quarter 1: January, February, March; Quarter 2: April, May, June; Quarter 3: July, August, September; Quarter 4: October, November, December. Area was divided into five areas that provided for a balanced design of observations of CPUE in all years, quarters, and in terms of target species (Figure 1). Restrictions were placed on the target species by eliminating the shark (SHX) and dolphinfish (DOL) target categories as having inadequate numbers of observations. Additionally, bigeye tuna (BET) and yellowfin tuna (YFT) were combined into the general tuna (TUN) category. There were three final target species levels: mixed (MIX), swordfish (SWO), and tuna (TUN). SST was interpolated from daily Sea-viewing Wide Field-of-view Sensor (SeaWiFS), Advanced Very High Resolution Radiometer (AVHRR) and Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery. Frontal regions were determined using an edge detection algorithm developed by Cayula and Cornillon (1992). Distance from nearest frontal region was then calculated using map algebra in ArcGIS 9. Hook depth and bottom depth were estimated by the observers onboard the vessels and were part of the U.S. observer database.

Similar analyses were used to develop standardized indices of abundance from U.S. based recreational fleets.

A surplus production model was fit to the data using the landings data and the abundance indices in ASPIC. In ASPIC, a data series consists of an index and a catch series. This analysis utilized three indices: 1) the U.S. Commercial Landings and the standardized abundance index estimated from the U.S. Pelagic Observer Programme (POP) longline fleet, 2) the U.S. Marine Recreational Fishing Statistical Survey, 3) and the U.S. Headboat data.

2.8.4.2 Results

The final model for the abundance index for the U.S. used four factors: year, quarter, SST, and area; and two interactions: year*SST and quarter*area to explain the variability in the nominal CPUE index (Figure 6). The abundance index was relatively stable with the steepest increase from 2000 to 2002 followed by a relatively steep decrease from 2002-2003. The incorporation of the random effect year*SST probably contributed the most to the width of the standard error bars. Based on the data available for the present study, mean catch rates (standardized catch per trip) of dolphinfish by the U.S. commercial fleet have fluctuated but generally remained constant during the period 1992 to 2003 (Figure 7).

The final model for the U.S. Marine Recreational Fishing Statistical Survey identified region and season as significant in explaining dolphinfish encounters, while no factors (region, season, area (distance from shore), or mode) significantly influenced catch per unit effort when dolphinfish were caught. The resulting standardized index is shown in Figure 8. The final model for the U.S. headboat data showed a significant effect of vessel for both encounter rate and catch per unit effort. For encounters, though, this factor led to model instability and thus could not be included. For catch per unit effort, it was included along with the significant interaction between vessel and year. Results are shown in Figure 8.

The runs in ASPIC yielded unreasonable estimates for initial biomass with starting estimates in the hundred million metric tons. A large number of runs were conducted that either fixed or estimated starting biomass, and varied the starting year for the model (1950, 1981, 1986). Though the model did not converge on a consistent best fit, all of the solutions suggested the stock was in virgin condition with essentially no impact whatsoever of current fishing rates. This result is not surprising considering a relatively flat abundance history during a time of great increases in catch. The Working Group did not believe that the optimistic result could be safely supported and recommended reconsideration of the assumptions behind the abundance indices and catch series.

2.8.5 Caribbean-wide assessments

2.8.5.1 Method/models/data

The methods for the Caribbean wide assessment assumed that the entire greater Caribbean basin contained a single stock of dolphinfish. ASPIC allowed us to model this using discrete fleets, each represented by its own catch history and catch rate index. This analysis utilized four indices: 1) the U.S. Commercial Landings and the standardized abundance index estimated from the U.S. Pelagic Observer Programme (POP) longline fleet, 2) the U.S. Marine Recreational Fishing Statistical Survey, 3) the U.S. Headboat data, and 4) the eastern Caribbean data series which consists of data from Barbados, Grenada, St. Lucia, St. Vincent and Dominica.

2.8.5.2 Results

Results of the ASPIC model were problematic. When initial biomass, MSY, and carrying capacity were all estimated, the model estimated a somewhat overfished starting population that recovered to healthy but not unrealistically so. However, these results were not well resolved in that the solution to the model changed with the starting point of the estimation procedure. Therefore, we tried running the model with starting biomass fixed at 80% of carrying capacity. The results of this run suggested the population was at virgin condition today, with no discernable impact from current fishing rates. These results were not deemed terribly likely by the Working Group, which recommended reconsideration of the assumptions behind the abundance indices and catch series.

2.8.6 Discussion

Given the lack of any concrete signs of a decline in catch rates over the ten-year study period (1995-2004), it may be concluded that catches of dolphinfish are sustainable at current levels of harvest. However, it should be noted that the effort data used in this assessment is somewhat weak for a number of reasons. For example, only records for successful fishing trips (in this case where dolphin landings were actually reported) could be used in these analyses. Without taking into account unsuccessful fishing trips (i.e. fishing trips where dolphinfish were targeted but not taken), values of mean annual catch per trip will necessarily be overstated. For the purposes of tracking inter-annual trends in catch rate, overestimating the actual values is of course not that important provided that the numbers of unsuccessful trips were fairly constant and therefore the degree of overestimation was also constant over the years. However, it must not be assumed that this is necessarily the case and future assessments should include some adjustment factor to account for the numbers of unsuccessful (with regards to dolphinfish) trips in each year.

In addition, few countries reported other effort information such as the length of the fishing trips, gear soak times and the numbers of gears used on each trip. Such information cannot be gleaned from general market data and must be obtained through more focused methods such as fisher interviews or trip logbooks. Authorities in the region should consider options for capturing this detailed information in the future. However, national surveys should be conducted to identify any historic changes at the gross level at least so that necessary adjustment factors may be included when assessing historic data series.

The failure to develop a trustworthy surplus production model using the ASPIC programme ultimately lies in the poor quality of available data. The FAO time series of catch data was comprised of reports from 15 countries in the WCA area. Of these countries data was only available from 1950 to the present for four countries (Barbados, Guadeloupe, Martinique and USA). In total only 345 of the possible 810 landings records for the 15 countries during the 54-year time span were actually reported in the database. Based on the very rounded and repetitive records, it appears that the catch records prior to 1974 at least were actually also estimates probably made by FAO at some point for all but the USA. Most of the Caribbean national records only start from the mid-1990's. Although the database was improved by inclusion of the reconstructed data in the cases of St. Lucia, Grenada and the Grenadines and St. Vincent and the Grenadines it can clearly be seen that the majority of the historic catch time series were actually estimates made by FAO scientists or this working group. Clearly much faith cannot be placed in the veracity of such an artificial database derived from so many assumptions.

The ASPIC modeling also failed through a lack of adequate measures of abundance through time. Ideally, abundance indices are developed from scientifically-designed surveys, which use consistent sampling methods over time. Surveys of this sort are rare in the region and the alternative is to examine catch per unit effort records. However, these indices may prove misleading when changes in fishing efficiency through improved techniques, gear etc. during the study period are not taken into account. As such it is necessary to reiterate the need for identifying these changes in fishing practices.

For the purpose of assessing a regionally shared stock, the dataset used for the present analyses was very limited both in terms of the number of fishing countries represented and the number of years for which records was provided. Given the importance of this species to most eastern Caribbean countries it is important that greater efforts be made to collect and provide the data needed for stock analyses in the future.

The FAO database still remains the most comprehensive source of historic fish landings in the region. It is likely that many fishing nations, particularly in the Caribbean may not have collected much accurate information on landings in the past decades on a regular basis. As such it will still be necessary to build historic catch records for the region largely by estimation. However, any contemporaneous information that addressed the state of the fishery in past years, especially landings data collected at various times for specific projects, advisory reports to government, student theses etc. that may reside only in "gray literature" would prove invaluable in guiding the reconstruction of the historic catch records. It is largely through this painstaking process that Mohammed (2003, and articles with colleagues following immediately after) was able to do the commendable job of reconstructing the landings data for the islands that they worked in. CRFM member states are therefore once again urged to "mine" such data and information to facilitate the reconstruction of their national historic catch series. Without a more solid and trustworthy regional historic database to work with it will be impossible to accurately determine key stock parameters such as biomass, MSY etc. for use in the management and development of the regions fisheries.

2.9 References

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2.8.8 Tables and Figures

Table 1. Estimated Catches by Fleet (mt), Regional References. Early catches were compiled on a country by country basis (and fleet by fleet for U.S.). Where unreported, early years were estimated by mimicking the patterns observed in nations where data were well reported (St. Lucia, St. Vincent, and Grenada for the southern fleet; US commercial for other U.S. fleets). Fleets shown here as they were entered in the model, with the choice driven by the need for relevant catch per unit effort indices for each fleet. These estimates did not include discards, which were assumed to be inconsequential. Northern and Southern fleets were distinguished based on the areas illustrated in Figure A. For nations that lay on the dividing line (i.e., Dominican Republic, British Virgin Islands), reported landings were split evenly between the northern commercial and southern fleets. Other northern fleets included the U.S.-based recreational headboat (vessels that accommodate large groups of recreational anglers) and other recreational fishing modes.

Year	SOUTHERN	N Commer.	N Other Rec	N Headboat
1950	1386	43	69	0.2
1951	1390	54	312	1.1
1952	1693	56	304	1.1
1953	1697	59	325	1.1
1954	1601	60	302	1.0
1955	1605	54	118	0.4
1956	1909	55	95	0.3
1957	2123	70	243	0.8
1958	2337	76	184	0.6
1959	2851	85	194	0.7
1960	2659	89	161	0.6
1961	2750	94	355	1.2
1962	2577	94	251	0.9
1963	2881	100	100	0.3
1964	3063	100	320	1.1
1965	2741	97	376	1.3
1966	3191	84	895	3.1
1967	4234	175	2189	7.6
1968	3378	155	1125	3.9
1969	3996	154	711	2.5
1970	3829	184	972	3.4
1971	3965	196	701	2.4
1972	4804	226	811	2.8
1973	4245	263	1041	3.6
1974	3962	348	1018	3.5
1975	5112	394	1573	5.5
1976	5142	353	1424	4.9
1977	5937	355	1690	5.9
1978	7293	333	1907	6.6
1979	6717	374	1294	4.5
1980	2820	500	1946	6.7
1981	2602	360	2107	5.3
1982	3031	486	3353	12.3
1983	4096	584	3323	12.8
1984	3854	400	2277	17.8
1985	4207	494	3457	17.0
1986	4677	963	4949	32.0

1987	3892	464	3625	29.0
1988	5063	675	3843	20.7
1989	3838	1108	6637	28.9
1990	4593	1633	6246	64.2
1991	4637	1860	8463	42.3
1992	5298	1256	5009	20.7
1993	4060	917	5959	28.9
1994	4240	1341	6463	17.8
1995	6097	1624	9694	32.2
1996	5753	1115	6468	24.6
1997	7238	2189	11206	22.0
1998	6771	1981	6283	11.5
1999	5935	1604	7048	24.6
2000	7129	1385	8189	34.0
2001	7180	1196	8082	35.2
2002	7930	2046	6720	22.3
2003	10028	1724	5989	10.4
2004	9150	2252	4843	15.4

Table 2. Summary of the numbers of records by country and year used for the catch rate analysis.

Year	Barbados	Dominica	Grenada	St Lucia	St Vincent	Total
1995	5540	974	-	3884	-	10398
1996	4449	-	726	2266	-	7441
1997	2774	980	235	2529	-	6518
1998	2850	727	457	2413	-	6447
1999	2500	572	779	2197	-	6048
2000	2474	-	29	1443	209	4155
2001	2432	727	-	2110	53	5322
2002	2584	1807	-	1743	-	6134
2003	2122	-	-	1445	177	3744
2004	2225	-	-	1652	-	3877

Table 3. Deviance table for selection of factors for inclusion in the final GLM model.

The explanatory factors in the base model are: Year							
Factor	Degrees of freedom (DoF)	Deviance	Deviance/DoF	% Reduction	Log likelihood	Chi Square statistic	Probability Chi Square
Base model	60074	99604.5	1.658	-100440.6			
Stategear	60070	67937.8	1.131	31.79	-88946.1	22988.99	0
Season	60073	96072.4	1.5993	3.54	-99356	2169.29	0
The explanatory factors in the base model are: Year State Gear							
Base model	60070	67937.8	1.131	-88946.1			
Season	60069	63848.8	1.0629	6.02	-87081.3	3729.71	0
The explanatory factors in the base model are: Year Stategear Season							
Base	60069	63848.8	1.0629	-87081.3			
Season*Stategear	60065	63204.2	1.0523	1	-86776.4	609.7	0
Year*Stategear	60033	63360	1.0554	0.71	-86850.4	461.77	0
Year*Season	60060	63735.6	1.0612	0.16	-87028	106.64	0

Table 4. Final GLM model statistics.

Tests of Between-Subjects Effects Dependent Variable: LNWT						
Source	Type III Sum of Squares	DoF	Mean Square	F statistic	Significance.	Eta Squared
Corrected Model	37886.349	14	2706.1678	2545.965	0	0.372402
Intercept	222038.36	1	222038.36	208893.9	0	0.776664
Year	262.64107	9	29.182341	27.45477	0	0.004097
Season	4089.0139	1	4089.0139	3846.948	0	0.060188
Stategear	32223.644	4	8055.9111	7579.008	0	0.33541
Error	63848.798	60069	1.0629243			
Total	997048.95	60084				
Corrected Total	101735.15	60083				
R Squared = 0.372 (Adjusted R Squared = 0.372)						

Table 5. Catch per unit effort from various sources as described in the text. All standardized indices values were normalized to average 1.

Year	Southern	Northern Commercial	Northern MRFSS	Northern Headboat
1981			0.575	
1982			1.034	
1983			0.809	
1984			0.795	
1985			0.617	
1986			0.628	0.873
1987			0.893	0.664
1988			0.800	1.070
1989			1.229	0.941
1990			1.331	1.867
1991			1.383	1.255
1992		1.258	1.073	0.641
1993		0.968	1.164	0.872
1994		0.876	1.073	0.756
1995	0.801	1.067	1.077	1.046
1996	0.915	0.789	0.740	0.878
1997	1.058	1.236	1.004	1.228
1998	0.964	0.876	0.975	0.719
1999	1.109	1.185	1.125	1.037
2000	1.094	0.635	1.431	1.198
2001	1.144	1.026	1.083	1.023
2002	0.985	1.422	1.229	1.138
2003	0.944	0.661	0.943	0.777
2004	0.985		0.990	1.019

Figure 1: Map showing study area divided in to statistical grids (#1-5) and distinguishing the southern stock area (in red) from the northern stock (the remainder).

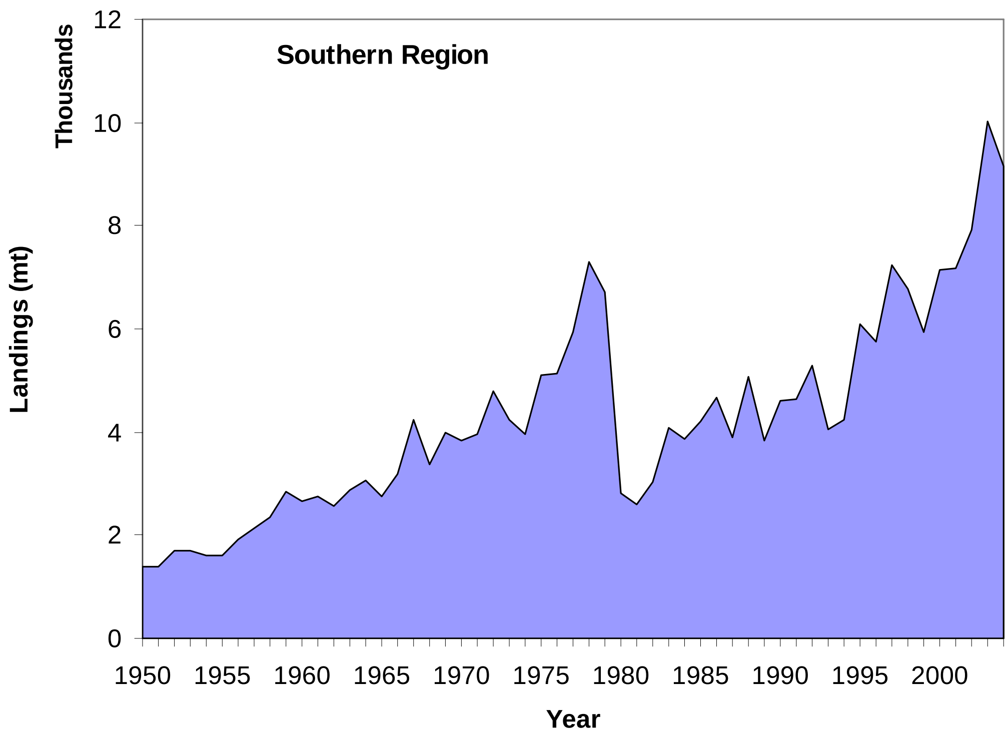

Figure 2: Landings from the Eastern Caribbean.

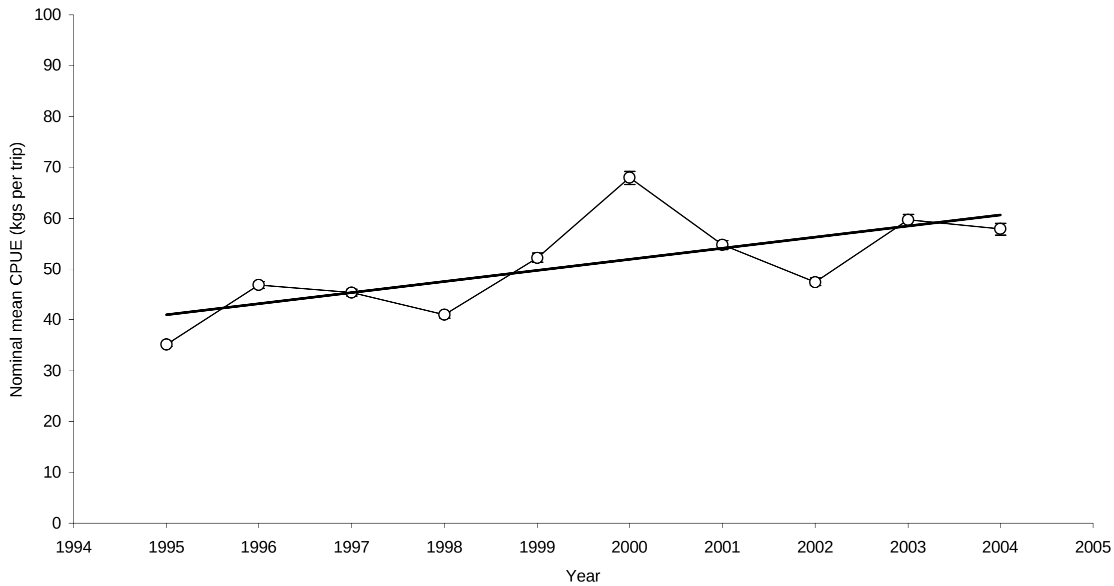

Figure 3: Nominal (non-standardized) mean CPUE for the Eastern Caribbean (1995-2004).

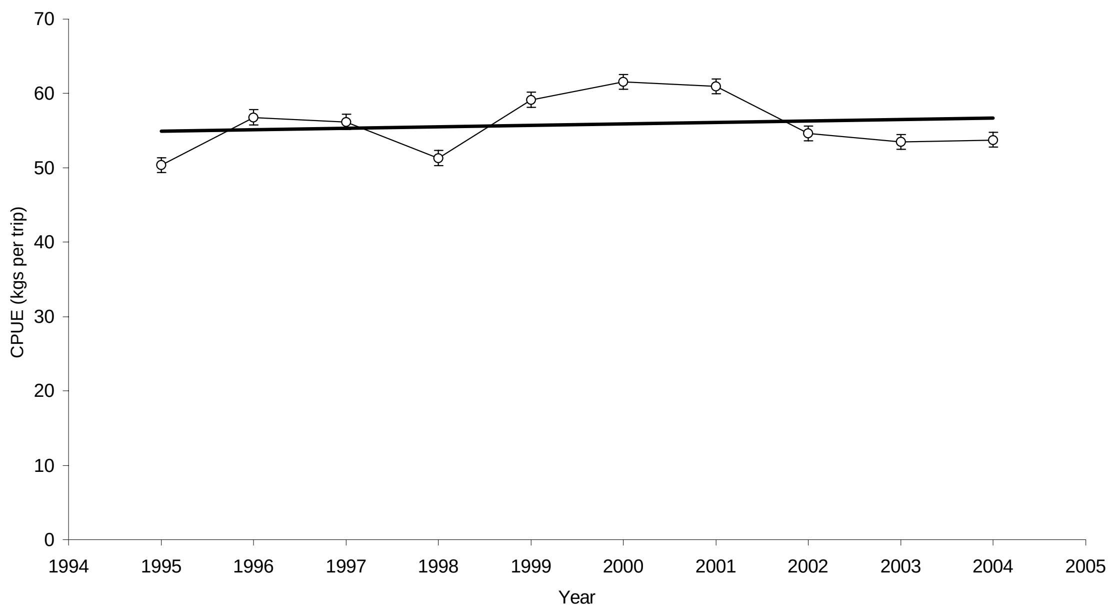

Figure 4: Standardized mean annual CPUE (including error bars) for the Eastern Caribbean (1995-2004).

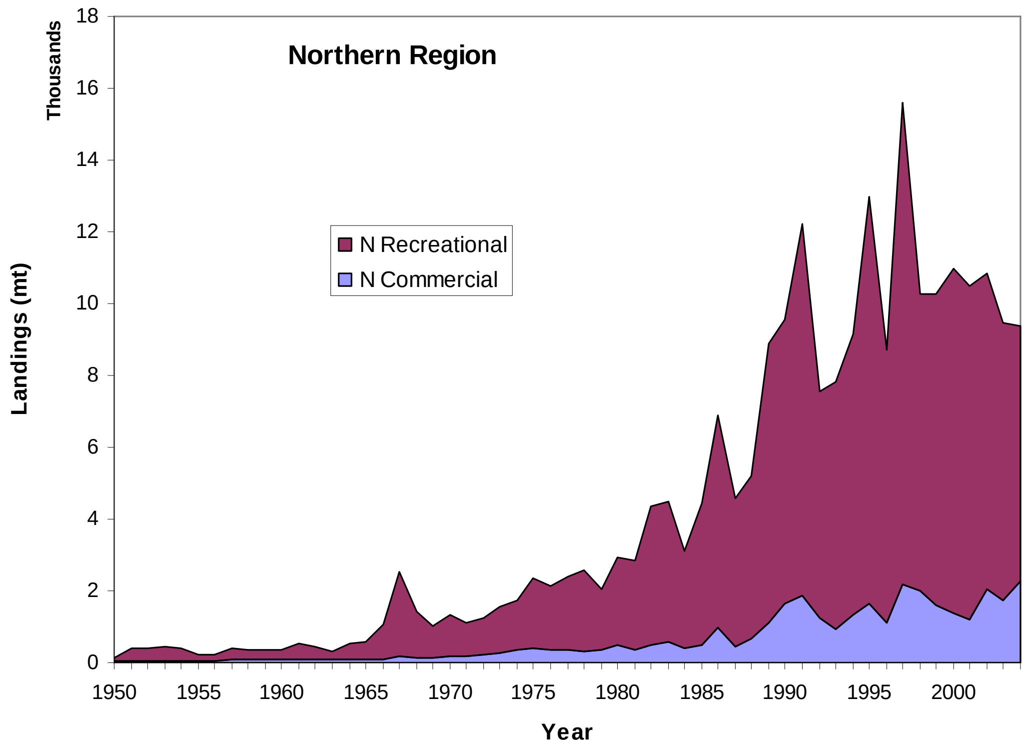

Figure 5: Annual landings of dolphinfish from the Northern Caribbean. Data taken from the National Marine Fisheries Service (NMFS) marine recreational fishery statistics survey (MRFSS) and commercial landings data from U.S. and northern Caribbean countries.

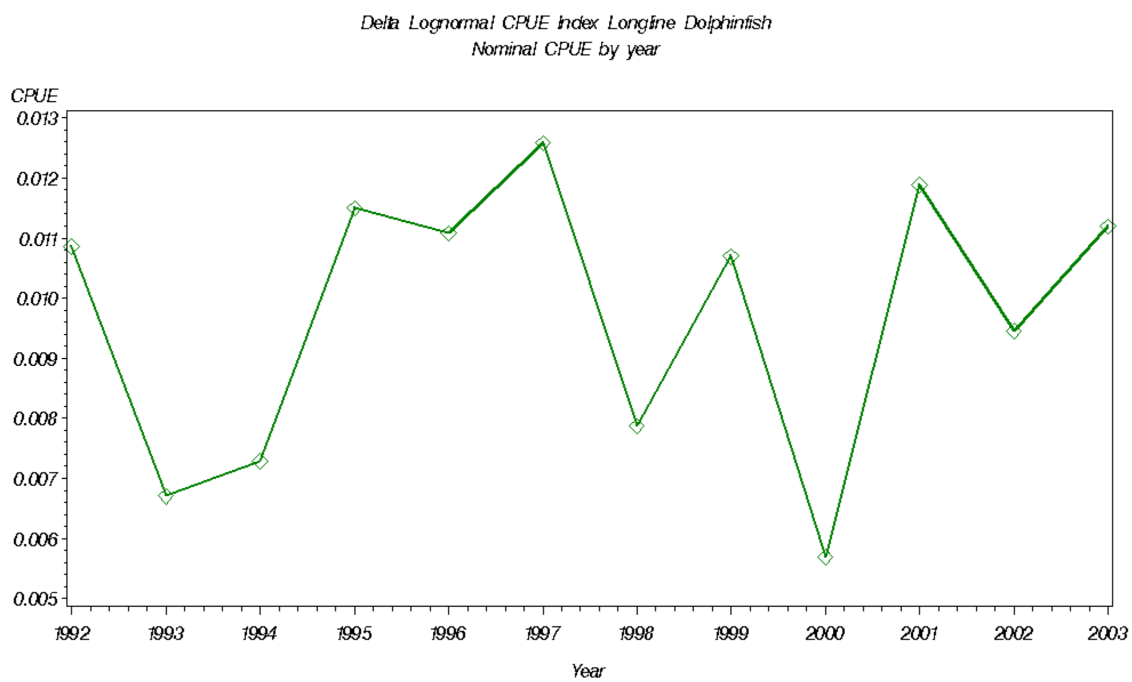

Figure 6: Nominal (non-standardized) mean CPUE for the U.S. commercial longline fleet (1992-2003).

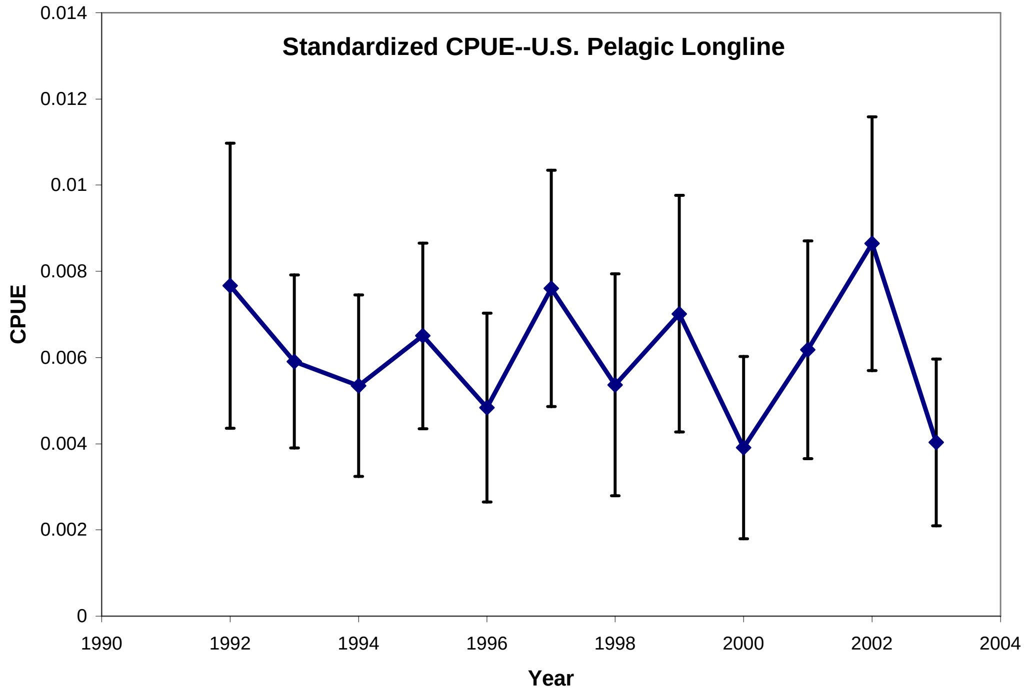

Figure 7: Standardized mean annual CPUE (including standard error) for the U.S. commercial longline fleet (1992-2003).

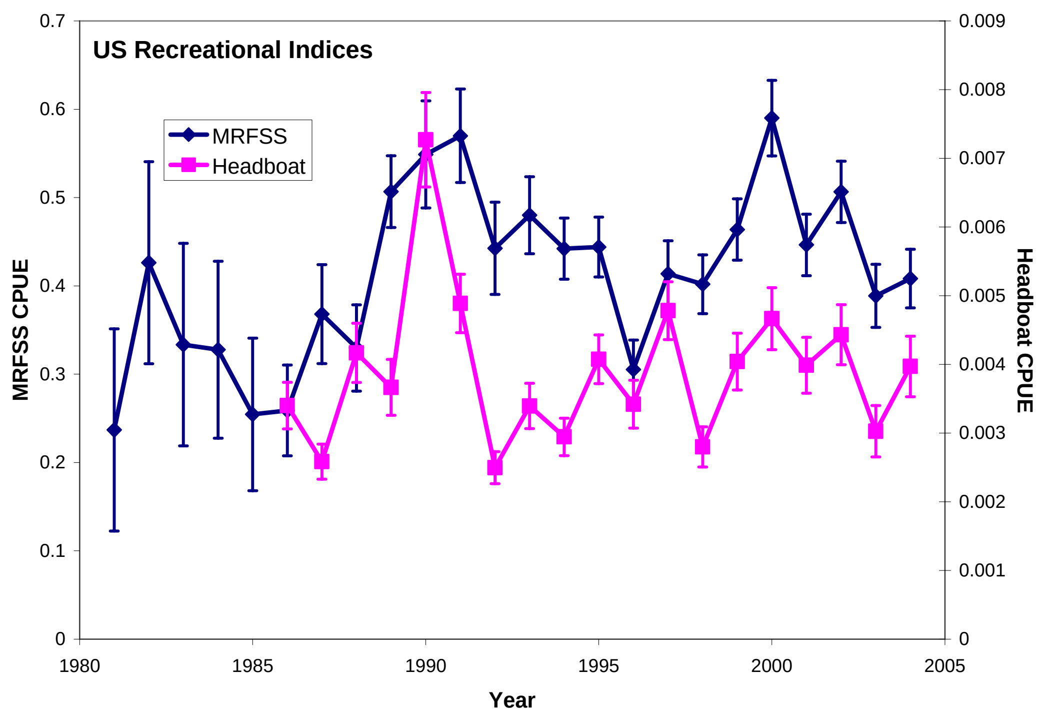

Figure 8: U.S. Recreational Abundance Indices. Standardized catch per unit effort from the U.S. recreational headboat and other recreational (MRFSS) sectors. Error bars represent one standard error around the mean.

Appendix 8: Reef and slope fish resources identified to be of importance to fisheries in CRFM States

CRFM State which presented information at the meeting	**Reef and Slope Resources of Current Importance to Fisheries**
Antigua and Barbuda	red hind
Barbados	queen snapper
Belize	mutton snapper, red hind, Nassau grouper, and lane snapper
The Bahamas	lane snapper and Nassau grouper
Dominica	Snappers and grunts
Jamaica	all species fished, but some present concerns about parrotfishes and yellowtail snapper
St. Kitts and Nevis	red hind and coney
St. Lucia	queen snapper and red hind
Montserrat	red hind and triggerfishes
Turks and Caicos Islands	all species fished, with Nassau grouper, red hind, and mutton snapper being most important
Trinidad and Tobago	red snapper