CARICOM Fishery Report No. 9

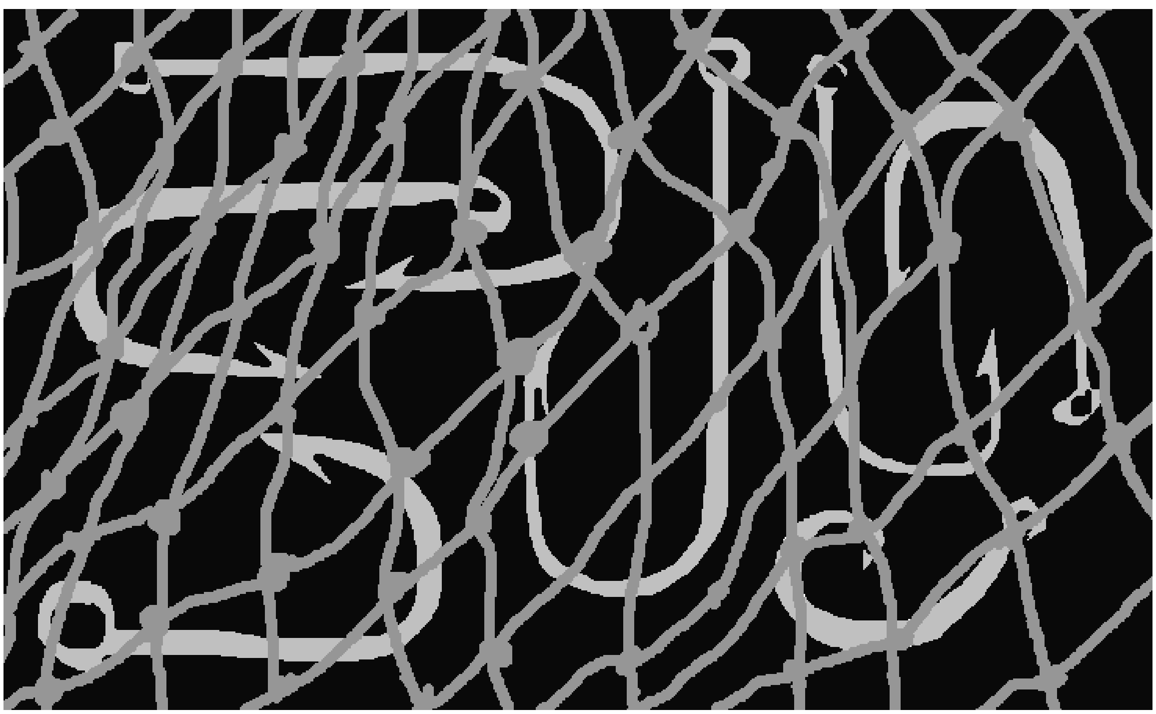
Caribbean Community Secretariat

CARICOM Fisheries Unit

Canadian International Development Agency

REPORT OF THE 2000 CARIBBEAN PELAGIC AND REEF FISHERIES ASSESSMENT AND MANAGEMENT WORKSHOP

June 5 - 7, 2000
Caribbee Hotel, Barbados



CARICOM FISHERIES UNIT, BELIZE CITY, BELIZE

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REPORT OF THE 2000 CARIBBEAN PELAGIC AND REEF FISHERIES ASSESSMENT AND MANAGEMENT WORKSHOP

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Executive Summary

In the 1990s, one of CFRAMP's main activities focused on the enhancement of fisheries data collection systems in the 12 CARICOM countries participating in the program. Recognizing that the enhanced data collection systems have since been maintained with variable success, recognizing also the need to analyse available data for provision of fisheries management advice, and appreciating the need to reinforce interest and effort in continually improving these data collection systems for sustainable fisheries management, CFRAMP convened the 2000 Caribbean Pelagic and Reef Fisheries Assessment and Management Workshop primarily to examine and to analyse available pelagic and reef fisheries data collected by CARICOM countries during the CFRAMP project. The present document is the official report of this Workshop, and consists of two parts: Part I provides a report of the Workshop sessions held during 5-7 June 2000; Part II of the report contains working documents which were presented and discussed during the Workshop.

Informed by the results of two CFRAMP biological data audits conducted in 1996 and 1997, Workshop preparations focused effort on compiling and analyzing available data from CARICOM countries on the following species: wahoo (*Acanthocybium solandri*), dolphinfish (*Coryphaena hippurus*), red hind (*Epinephelus guttatus*), and Atlantic thread herring (*Opistonema oglinum*). Working documents were prepared noting the methods and results of these analyses. Workshop participants recommended revisions and additions to the analyses conducted. Given time constraints, only minor revisions and additions were carried out during the Workshop sessions, and the relevant working documents were revised accordingly (see documents 4, 5, 6 and 10 in Part II of the report). Other recommended revisions and additions will be taken into account in future analyses of these data.

In addition to the four analyses noted above, other background working documents were prepared and presented during the Workshop. Document 7 gave a general statistical overview of the data analysed in preparation for the Workshop, Document 8 reported on the progress of fish age and growth research conducted by the CFRAMP/IMA Regional Fish Age and Growth Laboratory, and Document 9 introduced the use of fish stock assessment tools available from the internet. Documents 11, 12 and 13 were national reports providing country descriptions of the fisheries studied.

The preliminary assessment analyses of wahoo and dolphinfish fisheries used available data from 5 Eastern Caribbean territories: Grenada, Barbados, St. Vincent and the Grenadines, St. Lucia and Dominica. Length-based cohort analysis and yield per recruit analysis were attempted. Additionally, general linear model (GLM) analysis was used to examine spatial and temporal trends in catch rate and size of fish. In both fisheries, the length frequencies observed were largely unimodal, implying that the fisheries areas examined were harvesting only a portion of the whole stock. In view of this, the results of the length-based assessments remained questionable, and fisheries management advice was based more heavily on the observed GLM generated trends in catch rates. Both the wahoo and dolphinfish fisheries appeared to be relatively stable during the short time period (1995-1998) examined.

An assessment of the red hind fishery in St. Vincent and the Grenadines was conducted, using catch and effort and length frequency data collected during the CFRAMP project. Both the length-based assessment analyses and the GLM analyses indicated that the stock could be overfished. The Workshop noted that future analyses should try to determine the influence of a number of factors, such as area and gear type, on the estimation of total mortality, and should apply length-weight relationships from larger sample sizes. This highlighted the need for certain improvements in data collection particularly for the red hind fishery. Based on the results of the assessment analyses conducted, the Workshop recommended that red hind fishing effort in St. Vincent and the Grenadines not be further increased at this time.

There were sufficient data to perform only descriptive analyses of the Atlantic thread herring fishery in southern Jamaica. The results of these analyses indicated that the fishery was highly seasonal, based mainly on the occurrence of spawning aggregations. The fishery appeared to be self-regulating, with fishers seeking alternative employment during the “off-season”.

The Workshop also discussed and developed guidelines for incorporating fisheries assessment and management activities into the work programme of the CRFM, and these guidelines are presented in Part I of the report. Noting the progress achieved by the 2000 Workshop, participants recognized the importance of continuing the pelagic and reef fisheries assessments and recommended that a second workshop be held in 2001. The establishment of a regional working group to handle this work was also recommended.

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List of Abbreviations and Acronyms

CFU	CARICOM Fisheries Unit
CFRAMP	CARICOM Fisheries Resource Assessment and Management Program
CARDI	Caribbean Agricultural Research and Development Institute
CARICOM	Caribbean Community
CARISEC	Caribbean Community Secretariat
FAO	Food and Agriculture Organisation
ICCAT	International Commission for Conservation of Atlantic Tunas
IMA	Institute of Marine Affairs
OECS	Organisation of Eastern Caribbean States
UWI	University of the West Indies

PART I:

REPORT OF SESSIONS HELD DURING JUNE 5 - 7, 2000

Item 1: Opening Ceremony

The Opening ceremony commenced at 9.00 a.m., with opening and welcoming remarks made the Deputy Chief Fisheries Officer of the Barbados Fisheries Division, Mr. S. Willoughby. Mr. Willoughby welcomed participants, and noted the objectives of the workshop. In his closing remarks, Mr. Willoughby wished participants a successful workshop. On behalf of CFRAMP, Senior Biologist S. Singh-Renton, thanked the government of Barbados and the staff of the Fisheries Division of Barbados for their efforts and contributions in co-hosting the Workshop. Dr. Singh-Renton welcomed participants and acknowledged the presence of observers from the Barbados fisheries community, representatives from various regional and international research institutes and organisations. Dr. Singh-Renton urged participants to give their fullest in participation so as to ensure the success of the workshop. The feature address was given by the Minister of Agriculture and Rural Development, the Honourable Anthony Wood. Minister Wood acknowledged the work of CFRAMP in standardising data information systems in CARICOM countries, and setting the foundations for making the Workshop a reality. Minister Wood noted the importance of inclusion and consideration of social and economic information in the provision of fisheries management advice. Minister Wood also urged participants to give their full participation, and formally opened the Workshop. Ms. Angela Watson, president of the Barbados National Union of Fisherfolk Organisations (BARNUFO), gave the vote of thanks. She noted that BARNUFO was currently involved in the revision of the national fisheries management plan for Barbados, and expressed her hope that the outputs from the Workshop would assist this exercise, scheduled to be completed before the end of the year.

Item 2: Election of chairperson

The representative from St. Kitts nominated the Deputy Chief Fisheries Officer for Barbados, Mr. S. Willoughby, as Chairman for the plenary sessions. This nomination was seconded by the representative from Nevis. Mr. S. Smikle was selected to act as Deputy Chairman.

Item 3: Adoption of agenda and procedural arrangements

One minor change was made to the agenda. In addition, Agenda item 9 was withdrawn. Following these changes, the revised agenda was adopted (see ***Appendix 1***). A list of working documents is given in ***Appendix 2***.

Item 4: Introduction of country delegations

Delegates of CFRAMP countries introduced themselves. There was one delegate from each country except Trinidad and Grenada. There were two delegates from Nevis, and one delegate from Tobago. A complete list of CFRAMP country participants is given in ***Appendix 3***.

Item 5: Introduction of invited consultants and other observers

Present were several observers from the Fisheries Division of Barbados, and one independent observer, Ms. R. Delaney. Also present was Mr. P. Murray of the Natural Resource Management Unit (NRMU) of the Organisation of Eastern Caribbean States (OECS). Mr. P. Murray also represented Montserrat at the Workshop. In addition, two staff members of the CFRAMP/IMA Regional Fish Age and Growth Laboratory, Ms. R. Kishore and Ms. X. Chin, were in attendance. Dr. K. Cochrane (FAO), who is responsible for providing technical support for the United Nations Food and Agriculture Organisation (FAO) in the region, was invited as a consultant, and was introduced by Dr. S. Singh-Renton. Two other representatives from FAO, Mr. B. Chakallal and Mr. R. Walters were also introduced. Mr. B. Lauckner (Caribbean Agricultural Research and Development Institute, CARDI) was also invited as a consultant, and joined the Workshop sessions from Tuesday 6th. A list of observers is included in Appendix 3.

Items 6, 14, & 15: Assessment of red hind fishery in St. Vincent and the Grenadines

The detailed report was presented by L. Straker and S. Singh-Renton (see Part II). Given that data had been combined for all landing sites and all gears, it was noted that these factors could affect the fishery in different ways, and that these differences should be taken into account in the estimation of total mortality. It was pointed out that the length-weight relationship used in the assessments was based on a small sample of fish. In view of this, it may be useful to repeat the analyses using available length-weight relationships for red hind, which have been developed using larger samples from other islands in the Eastern Caribbean. There was some discussion about the quality of available data, and the amount of emphasis that should be placed on the short time series used for the analyses. Notwithstanding, there was some debate about the possible causes of an observed gradual decrease in the weight of fish caught per trip by ‘palangue’ (long line) gear since 1995. The question was asked whether there was any other evidence of a decline in the biomass of the red hind stock in St. Vincent & the Grenadines. The St. Lucia representative added that there was some anecdotal evidence that the biomass of certain reef fish species had declined in recent times in her country.

Given the results implied by the more detailed assessment analyses, it was considered necessary to examine annual trends in catch per trip and mean size of fish caught. These additional analyses were conducted during the working group sessions. The additional analyses and plots showed a decrease in catch per trip since 1995. The reasons for this are not clear. Given the continuing increase in the use of ‘palangue’ (long line) gear in recent years and the fact that this type of gear shows a higher catch rate than other gears, there was concern about the magnitude of the observed decrease. Moreover, the observed trends in catch rates supported the conclusions of the analytical assessment conducted. Mr. Straker noted the availability of additional data from September 1998 up to December 1999, which could be examined in the near future. If sample sizes are adequate, the data should be examined dis-aggregated by site and by gear. The additional analyses were incorporated into the final version of the detailed species report.

Management recommendations:

Noting that both the analytical assessments and statistical analyses of catch rates indicate that the red hind stock of St. Vincent & the Grenadines may be fully to over-exploited, it is recommended that

1) Fishing effort for red hind should not be increased beyond current levels in the near future.

Recognising, however, the need to separate the data for mainland and Grenadines catches, and the limitations of the length-weight equation applied here, it is recommended that

1) The assessment should be updated as soon as additional improved data become available.

Data and research recommendations:

Noting the significant progress made under the CFRAMP programme in the collection and analyses of fisheries and biological data, it is recommended that

1) Every effort should be made to continue, as well as to expand the current data collection programme to increase sampling coverage rates, and to collect information which would facilitate more detailed analyses of fishing effort and changes in fishing effort;
2) Age and growth studies using hard parts should be continued and completed for red hind. This study is currently in progress at the CFRAMP/IMA regional Laboratory.

Items 7, 14, & 17: Assessment of western Atlantic wahoo fishery using Eastern Caribbean data

The detailed report was presented by Ms. S. George (see Part II). Given that the length frequency data was strongly unimodal, there was some discussion regarding the 'true' interpretation of the catch curve presented. It was considered unreliable for the estimation of Z. This highlighted the importance of collaboration with other countries harvesting wahoo, both in terms of research and data and information exchange. The significant contribution of local sport fisheries to wahoo catches was noted, and there was some discussion about the possibility and the need to include these fisheries in future data collection programmes. As in the case of red hind, it was recommended that the catch data should be examined, dis-aggregated by factors such as gear, and landing site. In view of the small sample sizes, this recommendation may not be possible with the present dataset. Participants recognised the importance of updating analyses on a regular basis, and recommended that a regional Working Group should be established to address the assessment of highly migratory species such as wahoo and dolphinfish. The importance of continuing fish tagging studies was also highlighted.

Given the limitations of the available dataset, the lack of confidence in the estimation of total mortality, it was decided to examine in greater detail the annual trends of catch per trip for the most recent time period for which there was available data. These additional analyses showed no consistent decreases in catch per trip since 1995. In addition, there were no observed consistent decreases in mean fish size. There was considerable discussion about the changes in mean fish size with country and with gear type. The need to conduct analyses on data dis-aggregated by gear was reiterated. Moreover, participants recognised the importance of upgrading and expanding the current data collection programmes. It was agreed that the results of these additional analyses would be incorporated into the final version of the detailed species report.

Recommendations:

There was some concern about the low sampling coverage rate, and incompleteness of the dataset given the possibility of a total western Atlantic stock. Hence, the results of these assessments must be interpreted with caution. There were no apparent annual trends in mean catch rates (i.e., catch per days out). Similarly, mean fish size fluctuated with no definite trend. Given the uncertainty in the estimates of the basic stock parameters, greater emphasis was placed on the trend analyses for development of management recommendations at this time. Specific recommendations follow.

Management recommendations:

Noting the absence of any real trends in catch rates and mean fish size since 1995, which imply that the wahoo fishery in the Eastern Caribbean appears to be stable at current levels of fishing effort,

Considering, however, the potentially wide distribution of the wahoo fishery, possibly extending to the whole western Atlantic Ocean, and the subsequent limitations in using only the Eastern Caribbean dataset for determining the status of the stock, it is recommended that:

1) Wahoo fisheries should be expanded cautiously, if at all;
2) A broader regional assessment should be undertaken in the very near future, to improve our estimates of the basic stock parameters so as to generate better informed management recommendations for this fishery;
3) A regional Working Group should be established to address the assessment of highly migratory species such as wahoo and dolphinfish. Ideally, this Working Group should co-ordinate its activities under the aegis of the FAO WECAFC, in partnership with relevant sub-regional agencies.
4) Detailed assessments be undertaken on a regular basis to provide timely information on the status of wahoo stocks and appropriate management advice

Data and research recommendations:

Acknowledging that significant progress has been made under the CFRAMP programme in the collection and analyses of fisheries and biological data,

Noting the significant achievements of the current joint assessment undertaken by CFRAMP countries at the level of the Eastern Caribbean, *Noting also the importance of the wahoo fisheries to national and regional economies,*

Recognising the need to examine data from a wider area of distribution of the stock, it is recommended that

1) CFRAMP/CRFM countries should strive to maintain and improve their national data collection programmes, and sampling coverage rates for wahoo;
2) Mechanisms should be put in place to ensure that appropriate and detailed effort information is obtained on regular basis for the fishery, to allow for more accurate interpretation of catch and biological data (e.g. use of log books by fishers; annual effort surveys);
3) Sampling programmes should be expanded to include capture of data from the existing sport and longline fisheries, which harvest size ranges of wahoo that are different from those of the commercial fisheries;
4) CFRAMP, and subsequently the CRFM, should make every effort to continue to support the collection and analysis of good catch and effort and biological data at the country level, and to facilitate regular regional assessment of shared stocks;
5) Future regional assessments should include data from other countries which share the resource and which harvest substantial amounts of wahoo;
6) Future regional assessments should take into account the effects of gear selectivity;
7) Future regional assessments should include analyses incorporating social and economic information on the fishery;
8) The results of the CFRAMP/IMA wahoo age and growth study, particularly the value obtained for the growth constant ‘K’, should be considered in future assessments;
9) The CFRAMP fish tagging program should continue, as these studies yield valuable information on stock distribution, migration, as well as growth and mortality rates, useful for assessment and management purposes;
10) Other studies, such as the UWI/MAREMP genetic study of wahoo should continue, as these studies yield valuable information on stock identification, useful for assessment and management purposes.
11) CFRAMP, and subsequently the CRFM, should review the existing database, and identify information gaps for development of pertinent research projects.

Item 8: Age and Growth Studies at the CFRAMP/IMA Regional Age and Growth Laboratory

Ms. R. Kishore and Ms. X. Chin presented this report (see Part II). The report was very well received, and various participants acknowledged the quality and quantity of work achieved to date. It was noted that significant progress had been made in developing laboratory protocols, and the professional capability required for fish age and growth studies in the Caribbean. Participants acknowledged the adoption of a very scientific and professional approach to work by the Laboratory staff, and noted the importance of publishing completed work. The growth curve presented for wahoo was considered to be reasonable, and it was agreed that at least the ‘K’ value could be adopted for future assessments.

The need to pursue and develop validation studies and incorporate these into the future work of the Laboratory was highlighted. In view of limitations in resources, Ms. Kishore emphasized the necessity to maintain a practical workload for the laboratory; at present, the Laboratory has responsibility for ageing over 30 species. Participants agreed that the current workload was not sustainable. Participants recognised the need to develop their communication linkages with the laboratory, and expressed hope that regional co-ordination of this work would continue.

Recommendations:

Recognising the outstanding work progress and success of this joint CFRAMP / IMA activity, it is recommended that:

1) The Laboratory staff continue the good work, publish completed studies without further delays, and pursue validation studies in the near future;
2) The Laboratory's workload should be adjusted to focus on selected species of primary importance to fisheries managers, and to meet country demands under the Caribbean Regional Fisheries Mechanism (CRFM);
3) There should be frequent and regular communications between the Laboratory staff and fisheries staff in countries. The current communication linkages should be improved through circulation of work progress reports that include updated advice to countries concerning sampling, and regular participation in species assessment meetings requiring inputs from the Laboratory.

Item 9: The application of the CFRAMP/EU Biodiversity project to current assessment work

Mr. D. Neal presented this report (see Part II). Participants were informed of several stock assessment tools that are readily available over the internet. It was further noted that a Windows version of FISAT would become available in the near future.

There was some discussion about the sources and use of data quoted in FISHBASE, including the 'best' estimates of stock parameters.

Items 10, 14, & 18: Descriptive analyses of the Atlantic thread herring fishery in southern Jamaica

Ms. S. Grant presented the detailed report (see Part II). The results highlighted the fact that the present fishery targets spawning aggregations. The question of management of the fishery by application of a closed season was raised. However, the fishery has probably evolved as a result of the existence and timing of the spawning aggregation. Hence, management by this method could close the fishery completely, because the catches at other times would not compensate for the loss in catch during the peak periods. It was further noted that the fishery appeared to be self-regulating, with fishers seeking alternative employment during the 'off-season'. The importance of understanding the economic and social framework in which this fishery exists and manages to sustain itself was emphasized; such information could be useful in aiding future management decisions.

Management Recommendations:

Considering that the fishery appears to be self regulating, and

Noting the need to correct for gear selectivity prior to conducting stock assessment analyses, management recommendations for this stock are not considered at this time.

Data and Research Recommendations:

Acknowledging the significant progress made under the CFRAMP programme in the collection and analyses of these fisheries and biological data, and

Recognising the need to continue and develop the statistical and assessment analyses for Atlantic thread herring, it is recommended that

1) Every effort should be made to continue and expand the field data collection programme, so as to facilitate the analyses of (i) annual trends in catch rates and mean fish size, and (ii) the social and economic framework and operational structure of the fishery;
2) The data should be corrected for gear selectivity, to facilitate stock assessment analyses in future.

Items 11, 14, & 16: Assessment of dolphinfish fishery using Eastern Caribbean data

The detailed report was presented by Mr. C. Parker (see Part II). As in the case of wahoo, the problem of the unimodal distribution and the over-estimation of Z were reiterated. There was concern that the present assessment did not agree with the trends observed in an earlier catch rate series for Barbados. Given the limitations of the available dataset, the lack of confidence in the estimation of total mortality, and the fact that a historical catch rate series for Barbados showed relative stability of the fishery, it was decided to examine in greater detail the annual trends of catch per trip for the most recent time period for which there was available data. The plots of catch per days out showed no tendency to decrease over the 5 years studied. Additionally, the mean fish size fluctuated without any real trend since 1995. Large fish were observed in 1998, but this may have been due to shifts in the distribution of the stock as a result of the El Niño effect. There was considerable discussion about the changes in mean fish size with country and with gear type, which again highlighted the importance of upgrading and expanding the data collection systems. The need to conduct analyses on data dis-aggregated by gear was reiterated.

Management recommendations:

Noting the absence of any real trends in catch rates and mean fish size since 1995, which imply that the dolphinfish fishery in the Eastern Caribbean appears to be stable at current levels of fishing effort, no management recommendations are put forward at this time.

Considering, however, the potentially wide distribution of the dolphinfish fishery, possibly extending to the whole western Atlantic, and the subsequent limitations in using only the Eastern Caribbean dataset for assessment, it is recommended that

1) The assessment should be updated in the very near future, and should incorporate data from other countries with notable catches of dolphinfish.

Data and research recommendations:

Acknowledging the significant progress made under the CFRAMP programme in the collection and analyses of fisheries and biological data, and

Recognising the need to examine data from a wider area of distribution of the dolphinfish stock, it is recommended that

1) Every effort should be made to continue and expand data collection programmes, and to increase the sampling coverage rates;
2) Future assessments should include data from other countries which share the resource and which harvest substantial amounts of dolphinfish;
3) The results of dolphinfish age and growth studies using hard parts, particularly the value obtained for the growth constant ‘K’, should be considered in future assessments;
4) The CFRAMP fish tagging program should continue, as these studies yield valuable information on stock distribution, migration, as well as growth and mortality rates, useful for assessment and management purposes;
5) Other studies, such as genetic studies should be encouraged, as these studies could yield valuable information on stock identification, useful for assessment and management purposes.

Item 12: Statistical evaluation report of available fisheries data from five CFRAMP countries

Mr. B. Lauckner (CARDI) presented this report (see Part II). There was considerable debate about the usefulness and strength of TIP, with varying degrees of support for its continued use for fisheries data storage in CFRAMP countries. Several participants noted that TIP was a powerful programme, but noted concern that a Y2K version of TIP was not yet available. Additionally, the need for a Windows version of TIP was considered absolutely necessary, in order to maintain pace with the developing trends in computer software technology. If and when a replacement data storage system becomes possible, it would be important also to retain the data fields and their corresponding formats currently used in TIP. In this way, the important lessons learned through the development and evolution of TIP would not be lost by the introduction of an entirely 'new' system.

The need to continue improving data collection systems was emphasized. It was further noted that data quality checks should be performed on a routine basis, both at the national and regional levels. Participants recognised the importance of the present work in demonstrating the use of the data for fisheries management, and recommended that fisheries officers provide relevant feedback to data collectors, fishers and the general public regarding the progress of fisheries assessment and management work achieved to date. The continued use of General Linear Model (GLM) analyses was strongly encouraged. It was agreed that catch rate trends should be examined in detail on an annual basis.

Data Recommendations:

Acknowledging the advances made under the CFRAMP programme in the area of data collection, fisheries assessment and management activities, and

Considering CFRAMP's extensive and consistent effort to establish practical, comprehensive and 'user-friendly' data information systems, it is recommended that

1) National fisheries and biological data collection programmes should continue and be expanded;
2) Fisheries officers should provide relevant feedback to data collectors, fishers, and the general public. Such feedback would be important in popularising the ultimate intentions and goals of the field data collection programmes;
3) Either a 'Y2K Windows' version of TIP needs to be developed as soon as possible, or a replacement data storage system should be adopted. This replacement information system should be 'Y2K' compliant, operable in a 'Windows' environment, and should accommodate a seamless transition from TIP, in order not to lose the experience gained through the use of TIP.

Statistical Recommendations:

Noting the usefulness and essential applications of the statistical analyses performed during the assessments conducted for the 2000 Workshop, it is recommended that

1) Trends in catch rates and mean fish size should be examined on an annual basis;
2) General Linear Modelling (GLM) techniques should continue to be used as a tool for statistical analyses, particularly to test and to aid interpretation of the significance of observed trends.

Items 13 & 19: Guidelines for incorporating fisheries assessment and management in the work programme of the CRFM

S. Singh-Renton introduced this topic, and presented various points that could be considered for further discussion. Following this, there was some debate about the items that should receive the groups' focused and detailed attention. A few participants attempted to summarise the activities and the conclusions of the third RFM Workshop held in Jamaica in April 2000. A preliminary list of items for further discussion and development was prepared. It was then agreed that a small working group should deal with this task, and present its conclusions during the second session of this topic. The representative from Dominica chaired the session of the small working group. The guidelines developed by the small working group were adopted with minor changes, as follows.

Guidelines:

Noting the progress made regarding the establishment of the Caribbean Regional Fisheries Mechanism (CRFM),

In agreement with the recommendations proposed in the Report of the Working Group on the Caribbean Regional Fisheries Mechanism, and

Recognising the essential role of the CRFM in coordinating assessment and management of the region's shared fisheries resources, the following guidelines are proposed for incorporating fisheries assessment and management activities into the work programme of the CRFM:

1) The CRFM should assist in improving/upgrading, expanding, and standardising data collection systems. In particular, the CRFM should assist in:
   - designing these systems
   - determining areas of improvement
   - facilitating any refinements/improvements to these systems.
   - training / capacity building for conducting assessment and related data analyses.

<u>NB</u>. Individual countries must identify and priorise the species to be analysed, based on specific management needs. In the past, species of commercial value have been overlooked and other less commercially important species have been analysed. Also, too many species are presented for analysis.

2) The CRFM should co-ordinate and facilitate the assessment and management of shared resources.

3) The CRFM should assist in assessment and monitoring of coastal and fish habitats (e.g. determine relationships between habitat and catch rate).

4) The CRFM should facilitate a medium for the efficient / effective 'user-friendly' handling and storage of fisheries data. This should be a preparatory activity for the setting up of the CRFM.

5) The CRFM should determine ways of quantifying discards / by-catch, and of incorporating this activity into the ongoing data collection programmes.

6) The CRFM should incorporate social and economic information into fisheries assessment, management and planning. As a preparatory activity, a frame survey should be developed which should be used as a tool to gather 'socio-economic' information on the fisheries being assessed.

7) The CRFM should formulate management advice on shared stocks at the regional level, based on assessment results.

Item 20: Date and place of 2001 workshop

Participants noted the importance of continuing analyses of pelagic and reef fisheries data, and holding assessment meetings to examine the status of these stocks on a regular basis. There was again some discussion about the possibility of establishing a regional working group on dolphinfish and wahoo under the aegis of FAO WECAFC, and the timing of the next workshop in view of this. It was not considered appropriate or desirable to extend the current FAO flyingfish working group to include wahoo and dolphinfish. S. Singh-Renton advised that CFRAMP would be interested in hosting a second workshop in 2001, given available funding.

Item 21: Other business

This Item was devoted to additional discussions concerning the future use of the TIP data storage software. As noted under Agenda Item 12, participants recognised the usefulness and power of the TIP programme for fisheries data storage and management purposes, but remained concerned that programme 'bugs' continue to pose setbacks and that a Windows version of TIP was not yet available.

Recommendations:

Recognising the valuable contribution of the TIP programme to fisheries management in CFRAMP participating countries,

Appreciating highly the full potential of the TIP programme,

Acknowledging the immense effort of CFRAMP (and others working with CFRAMP) to make the programme available to CFRAMP member countries, and to provide users with adequate information and training in software usage,

Noting however, that there are several limitations to the TIP software that prevents eager and ready adaptation and usage in CFRAMP member countries, including: (i) a poor interface, (ii) problems with year 2000 date compatibility, and (iii) operating system compatibility, it is strongly recommended that

CFRAMP or the CRFM, facilitate the introduction of a windows version of TIP as soon as possible. The windows version of TIP should be: fully Y2K compliant; facilitate networking including via the internet; and be fully compatible with future operating systems (including all future Windows systems), which will not provide backward compatibility with programmes based on 8 or 16 bit kernels.

Item 22: Finalisation and adoption of workshop report and closure of plenary sessions

A preliminary draft of items 1 - 20 was photocopied and circulated. Participants made revisions and corrections, after which this first draft of the report was adopted.

Participants expressed their satisfaction of the work progress achieved, and noted the importance of continuing the work of pelagic and reef fisheries assessments. It was assumed that the co-ordination of inter-sessional activities would be the responsibility of the agency funding the 2001 workshop.

Following these general comments, the Deputy Chairman formally closed the plenary sessions.

Appendix 1

Working Document: CFRAMP_PRFA/2000-01

REVISED AGENDA

1. Opening ceremony
2. Election of Chairperson
3. Adoption of Agenda and procedural arrangements
4. Introduction of country delegations
5. Introduction of invited consultants and other observers
6. Assessment of red hind fishery in St. Vincent & the Grenadines – session 1
7. Assessment of western Atlantic wahoo fishery using Eastern Caribbean data - session 1
8. Age and Growth Studies at the CFRAMP/IMA Regional Age and Growth Laboratory
9. The application of the CFRAMP/EU Biodiversity project to current assessment work
10. Descriptive analyses of the Atlantic thread herring in southern Jamaica
11. Assessment of dolphinfish fishery using Eastern Caribbean data – session 1
12. Statistical evaluation report of available data from five CFRAMP countries
13. Recommendations for fisheries assessment and management in the work programme of the Caribbean Regional Fisheries Mechanism (CRFM) – session 1
14. Species Assessment Working Group (WG) sessions
15. Assessment of red hind fishery in St. Vincent & the Grenadines – session 2
16. Assessment of dolphinfish fishery using Eastern Caribbean data – session 2
17. Assessment of western Atlantic wahoo fishery using Eastern Caribbean data - session 2
18. Analyses revisions and additional analyses of other species: Atlantic thread herring in southern Jamaica.
19. Recommendations for fisheries assessment and management in the work programme of the Caribbean Regional Fisheries Mechanism (CRFM) – session 2
20. Date and place of the 2001 workshop
21. Other business
22. Finalisation and adoption of Workshop report and closure of plenary sessions.

Appendix 1 (continued)

Working Document: CFRAMP_PRFA/2000-02

REVISED ANNOTATED AGENDA

Monday, June 5th, 2000 (morning)

1. Registration (*8.00 - 9.00 a.m.*)

2. Opening ceremony (*9.00 - 9.30 a.m.*)

3. Election of Chairperson (*9.40 - 9.45 a.m.)*

4. Adoption of Agenda and procedural arrangements (*9.45 - 9.55 a.m.)*

5. Introduction of country delegations (*9.55 - 10.25 a.m.)*
   - introduction of delegates

6. Introduction of invited consultants and other observers (*10.25 – 10.45 a.m.)*

   Coffee Break *(10.45 - 11.00 a.m.)*

7. Assessment of red hind fishery in St. Vincent & the Grenadines – session 1 (*11.00 a.m.- 12.15 p.m.*)
   - presentation of 2000 report
   - review and discussion

8. Assessment of the western Atlantic wahoo fishery using Eastern Caribbean data - session 1 (12.15 p.m. – *1.30 p.m.)*
   - presentation of 2000 report
   - review and discussion

   Lunch *(1.30 p.m. –2.30 p.m.)*

Monday, June 5th, 2000 (afternoon)

9. Age and Growth Studies at the CFRAMP/IMA Regional Age and Growth Laboratory *(2.30 - 4.00 p.m.*)
   - overview of work achieved
   - future approaches

   Coffee Break (*4.00 – 4.15 p.m.*)

10. The application of the CFRAMP/EU Biodiversity project to current assessment work (4.15-5.00 p.m.)
    - relevant FISHBASE upgrade features
    - conducting literature reviews for information on species biology, population dynamics, etc.
    - data analyses within FISAT (importing data, file manipulation, etc.)

Tuesday, June 6th, 2000 (morning)

11. Descriptive analyses of Atlantic thread herring fishery in southern Jamaica (8.30-9.15 a.m.)
    - overview of available information and work achieved

12. Assessment of dolphinfish fishery using Eastern Caribbean data - session 1 *(9.15 a.m. – 10.15 p.m.*)
    - presentation of 2000 report
    - review and discussion

    Coffee Break *(10.15 - 10.30 a.m.*)

13. Statistical evaluation report of available fisheries data from five CFRAMP countries *(10.30 – 11.15 a.m.)*
    - Preparation of data for analysis (cleaning of data, quality checks, etc.)
    - what to expect from the data we collect (what our data can tell us about our fisheries)
    - advantages of further analyses from minor improvements in data collection.

14. Recommendations for fisheries assessment and management in the work programme of the Caribbean Regional Fisheries Mechanism (CRFM) (*11.15 a.m.- 12.30 p.m.*)
    - discussion and development of guidelines for incorporating fisheries assessment and management activities into the CRFM
    - national and regional preparatory activities

    Lunch *(12.30 p.m. – 1.30 p.m.)*

Tuesday, June 6th, 2000 (afternoon)

15. Species Assessment Working Group (WG) Sessions (red hind, atlantic thread herring, wahoo and dolphinfish) (*1.30 p.m. – 5.00 p.m.*)
    - further development of statistical and assessment analyses

    Coffee Break (*4.00 – 4.15 p.m.*)

Wednesday 7th June, 2000 (morning)

16. Assessment of red hind fishery in St. Vincent & the Grenadines - session 2 (8*.30 – 9.15 a.m.*)
    - review and discussion of WG analyses revisions
    - finalisation and adoption of 2000 report

17. Assessment of dolphinfish fishery using Eastern Caribbean data – session 2 (9*.15 – 10.00 a.m.*)
    - review and discussion of WG analyses revisions
    - finalisation and adoption of 2000 report

18. Assessment of western Atlantic wahoo fishery using Eastern Caribbean data - session 2 (10*.00 – 10.45 a.m.*)
    - review and discussion of WG analyses revisions
    - finalisation and adoption of 2000 report

    Coffee Break (*10.45 - 11.00 a.m.*)

19. Analyses of other species: Atlantic thread herring fishery in Jamaica (*11.00 – 11.45* a.m.)
    - review and discussion of analyses revisions and additional analyses
    - finalisation and adoption of 2000 report

20. Recommendations for fisheries assessment and management in the work programme of the Caribbean Regional Fisheries Mechanism (CRFM) – session 2 (*11.45 a.m. – 12.30 p.m.*)
    - completion of discussions

    Lunch *(12.30 p.m. – 2.00 p.m.)*

Wednesday, June 7th, 2000 (afternoon)

21. Date and place of 2001 workshop. (*2.00 - 2.10 p.m.*)

22. Other business (*2.10 – 2.20 p.m.*)

23. Finalisation and adoption of Workshop report (*2.20 - 4.00 p.m.*)

    Coffee Break (*4.00 – 4.15 p.m.*)

23. (continued). Finalisation and adoption of Workshop report and closure of plenary sessions (4.15 – *5.00 p.m.*)

Appendix 2

Working Document: CFRAMP_PRFA/2000-03

LIST OF WORKING DOCUMENTS

CFRAMP_PRFA/2000-01: Agenda

CFRAMP_PRFA/2000-02: Annotated Agenda

CFRAMP_PRFA/2000-03: List of Working Documents

CFRAMP_PRFA/2000-04: Assessment of wahoo (*Acanthocybium solandri*) fishery using Eastern Caribbean data – S. George, S. Singh-Renton, and F. B. Lauckner.

CFRAMP_PRFA/2000-05: Assessment of dolphinfish (*Coryphaena hippurus*) fishery using Eastern Caribbean data – C. Parker, S. Singh-Renton, and F. B. Lauckner

CFRAMP_PRFA/2000-06: Assessment of red hind (*Epinephelus guttatus*) fishery in St. Vincent & the Grenadines – L. Straker, S. Singh-Renton, and F. B. Lauckner.

CFRAMP_PRFA/2000-07: Statistical evaluation report of available fisheries data from five Eastern Caribbean territories – F. B. Lauckner

CFRAMP_PRFA/2000-08: Age and growth studies at the CFRAMP/IMA Regional Age and Growth Laboratory – progress of work done and future approaches – R. Kishore and X. Chin.

CFRAMP_PRFA/2000-09: Requirements for doing quantitative fish stock assessment, using tools readily available on the web - D. Neal.

CFRAMP_PRFA/2000-10: Descriptive analysis of the Atlantic thread herring (*Opistonema oglinum*) on the south coast of Jamaica – S. Grant, J. Gordon, and S. Singh-Renton.

CFRAMP_PRFA/2000-11: National report of Trinidad and Tobago: Pelagic and reef fisheries – Tobago - A. D. Thomas, A. C. Potts, E. Nichols and F. Mukhida.

CFRAMP_PRFA/2000-12: National country report of St. Vincent & the Grenadines for dolphinfish (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), red hind (*Epinephelus guttatus*) and coney (*Cephalopholis fulva*) - L. Straker and C. Jardine.

CFRAMP_PRFA/2000-13: A description of the dolphinfish (*Coryphaena hippurus*) fishery of Barbados – C. Parker.

Appendix 3

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PART II:

WORKING DOCUMENTS
(NUMBERS 4-13)

Working Document: CFRAMP_PRFA/2000-04

Assessment of Wahoo (*Acanthocybium solandri*) Fishery using Eastern Caribbean Data

Rapporteurs: S. George[1], S. Singh-Renton[2], B. Lauckner[3]

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Introduction

The Wahoo, *Acanthocybium solandri* (Cuvier), is a pelagic fish species targeted by the offshore fishery throughout the Eastern Caribbean, particularly the Windward Islands and Barbados. These fisheries are primarily small-scale. Notwithstanding, the offshore fishery often comprises the bulk of the annual catch of these countries, thus making an important contribution to GDP and the local protein supply. The stock is presumed to migrate throughout EEZs of the Eastern Caribbean, although little is known about the extent to which the species migrates or the stock structure within the Western Central Atlantic (Mahon, 1996). These Eastern Caribbean fisheries operate mainly along the eastern side of the windward island chain and to the south and west of Barbados.

Fishing vessels range from small open canoes and open fibreglass pirogues (20-30 ft) with 15-85 hp outboard engines to the larger inboard diesel-powered day launches and ice-boats of Barbados. The traditional wooden, canoe is still utilised for the offshore fishery, but in most islands the conversion to the larger, more stable pirogue has progressed quite rapidly, particularly during the past 5-8 years. The ice-boats of Barbados have ice-holds with storage capacity of 4-12 mt and are able to stay at sea several days.

The primary gear is hook and line, usually deployed using either trolling or hand lining techniques. During a single trolling trip, 1-3 lines (120-180 ft, 120-160 lbs tested monofilament line) may be fished simultaneously, and each line may have up to 3 hooks, although often only one hook is used. Hand lines may also have several hooks to each line, and are normally deployed when the boat is stationary/drifting. A variety of hook types and sizes are used, ranging from smaller stainless steel hooks (nos. 5-9) in islands such as St. Vincent and the Grenadines to larger aluminium hooks (nos. 21-22) in Grenada. Hooks are baited with either fresh dead fish bait and/or artificial lures. Crew size per boat averages 3 (this includes the captain).

Fishers tend to use seabird congregations and drifting objects to suggest likely congregations of wahoo and other migratory pelagics. The average trip is of 8-12 hours duration, inclusive of travel and search time. Directed fishing effort occurs primarily during the months of November to July.

Nevertheless, in all of the Windward Islands an emerging longline fishery exists, operated by larger pirogues and decked vessels using mechanised mid-water and surface-set longlines with 3-10 miles of line and 100-500 hooks. Wahoo is largely taken as by-catch by this fleet for which the primary target species are large tunas. Longline trips tend to vary from one to 8 days in duration and navigational and fish-finding equipment may be used.

Wahoo landings reportedly showed a steady but slow increase for many Eastern Caribbean countries from the 1970s through to the 1980s, followed by a more rapid increase during the early 1990s (Mahon, 1996). Recent trends imply fluctuations in the landings for most countries (figure 1). During the same period, both fishing effort and capacity have increased. In most/all of these countries, the numbers of vessels and fishers have increased, with the individual vessel capacity also tending to increase in many cases with the conversion to the larger pirogues, launches and small long-liners.

A comprehensive review of the biology of wahoo is currently being conducted (Murray *et al*., in prep.). This paper notes that there has been little research specifically on wahoo, with no systematic attempt to estimate regional abundance of wahoo to date. Hunte (1987) noted an increase in the average annual catch per trip for the Barbadian "kingfish" fishery (which comprises mostly wahoo and some king mackerel), between 1960 and 1982, which he speculated was probably due to an increase in fishing power per trip. In comparison, Mahon, *et al.* (1990) found significant inter-annual and inter-seasonal variability in wahoo catch per unit effort in Barbados, Saint Lucia, Saint Vincent and the Grenadines and Grenada. Murray et al. (in prep) note that, in many cases the results of past studies on catch rates and seasonality of abundance are often obscured the fact that commercial landings of "kingfish" probably relate to king mackerel as well as wahoo. However, both Hunte (1987) and Mahon *et al*. (1990) found wahoo catches to be poorer from July to November, with two or three modes arising during the remainder of the year.

Length-based analyses of wahoo in the Eastern Caribbean are also limited to date, with Murray (1989) finding several modes within the length distribution for wahoo captured in Saint Lucia with a size range of 74.3 cm FL (2,048 g) to 134.6 cm FL (13,800 g). Studies of size and age at maturity are limited but suggest full maturity by age and a life span of 5 or 6 years (Murray *et al*., in prep). Quoted estimates for L_∞ , obtained from length-based analyses, range from 150 to 194 cm fork length (FL), and estimates for the growth rate parameter K, range from 0.675 y^{-1} to 4.26 y^{-1} (Murray, (1989), and De Souza *et al.*, unpublished, cited in Murray *et al.*, in prep). Also, Murray (1989), working on wahoo from Saint Lucia, obtained an L_∞ of 141 cm (TL) and a K of 3.93 y^{-1} when back calculating age in days from sagittal markings presumed to be daily growth rings. Additional St. Lucian studies estimated L_∞ to range from 156 cm to 161 cm and K of 0.31 to 0.37 y^{-1} (Murray and Sarvey, 1987; Murray and Joseph, 1996). The estimation of stock parameters based on analyses of length data from the Saint Lucia fishery are considered to be biased due to lack of modal progression exhibited by the length frequency data (Murray *et al.,* in prep.).

The present report documents current efforts to complete a first assessment of the wahoo fishery, using Eastern Caribbean data. CFRAMP funded activities in the early 1990s facilitated an upgrade in the data information systems in 12 CARICOM countries, and this upgrade included the establishment of biological data collection and data storage systems in 1995. The additional data collected under these activities are used for the present study. All available data were obtained from those CFRAMP countries with major fisheries for this species: Grenada, St. Lucia, St. Vincent and the Grenadines, Barbados, and Dominica. In the case of Grenada and Dominica, data from 1997 and 1996 respectively were not available in a computerised format at the time.

Preparation of data for analysis

Biological data have been collected from 1995 to 1999, although the degree of completeness differs among the 5 countries and years. In each country the sampling program was designed to sample landings and to collect information on fishing effort in order to estimate total landings per species (in some cases for species groupings) per month per fish landing site. Due to resource limitations, all landing sites were not sampled. Hence, sites were stratified (e.g., into primary, secondary and tertiary sites) and an adequate number of sites within each stratum was sampled to ensure adequate, unbiased sampling coverage. Additionally, not all days were sampled at all sites (some sites are now being censused), in which case a pre-determined number of sample days were allocated to each site.

Catch and effort data collected include information on: target fishery, trip length, hours fished, vessel identification, number and type of gear, crew size, numbers of sets per gear, mesh size used (where applicable), location and range of depths fished, species caught and their corresponding total weight (either measured or estimated, with the type of weight, i.e., whole or gutted, in kg or lbs). Biological data include: species, length frequency data, and the number and weight of fish in the length frequency sample. The data on individual fishing trips were computerised using the Trip Interview Programme (TIP), modified for Caribbean fisheries (Gold 1990; Murray and Barnwell, 1994).

To conduct the present analyses, extractions of all relevant fields within TIP (i.e., TIP database files TIP11, TIP12, TIP13, TIP21, TIP 31, TIP41) pertaining to catch and effort as well as biological data for each available year were performed. Each country was also required to generate datasets detailing raised catches for wahoo from their sampled data, using their individual raising methodologies, reporting total catch per month.

Prior to conducting analyses on the pooled datasets for the catch and effort and the biological data, the files were screened for errors (e.g., outliers that indicated data entry errors, replicate entries, empty cells) using various plotting and tabulation procedures available in SPSS (Version 8.1) and Excel (97). All anomalies were either adjusted if the apparent error was obvious or omitted from the analyses if necessary.

Examination of the data revealed that monthly sample sizes were too low (< 80 fish sampled) for most months in 1995, but were reasonable in 1996-1997 and the first half of 1998. This was probably due to the fact that many countries experienced a slow start in their biological sampling programmes in 1995, and countries down-sized their sampling programmes following the cessation of activity funds by CFRAMP around mid-1998.

In Barbados, St. Vincent and the Grenadines, and Grenada, catch data were recorded in gutted weight, with round weights recorded in St. Lucia and in Dominica. During February 1999, St. Lucian fisheries staff collected data on round weight, gutted weight, fork length, and sex from a sample of 24 wahoo (George, pers comm). These data were used to determine equations describing the relationships between round and gutted weight, and between fork length and round weight. Given the small sample size, these relationships may have to be improved with additional sampling in the near future. A much larger sample of wahoo (> 100 fish) was studied by IMA staff (Kishore, pers comm): their fork length - weight equation was found to differ significantly from the corresponding St. Lucian equation. This difference may be artificial owing to the small size of the St. Lucian sample. Notwithstanding, given the possibility of real differences between the Eastern Caribbean fisheries and the southern Caribbean fishery from which the IMA sample originated, the St. Lucian length-weight conversion equation (George's equation) was adopted for the current assessment. Barbados did not record the weight of wahoo catch sampled for lengths. Hence, in the case of Barbados, the individual sampled fish weights were reconstructed using George's equation.

The monthly sampled catch-at-size data matrix (1995 to 1998), required for input into FISAT for Modal Progression Analysis (MPA), was developed using SPSS' cross-tabulations procedure (fork length data in rows, and each month in a separate column). This matrix was then exported into EXCEL where the data were aggregated by 5-cm length intervals and the layout edited for direct import into FISAT. Six fish measurements, ranging from 9 to 20 cm, were noted. There was some doubt whether these small sizes of wahoo could be caught; for this reason they were not included in the present analysis, but future sampling should help to resolve this issue. Given that the included sampled wahoo lengths ranged from 27 cm to 174 cm, and the FISAT upper limit of 50 length intervals, there was a choice of using length intervals of either 4-cm or greater. We decided to use length intervals of 5-cm for the current assessment, as it was easier to work with, and any improvement to MPA by reduction to 4-cm intervals may have been negligible for the wahoo case. Notwithstanding, it may be useful to redo the MPA using 4-cm intervals to confirm this statement.

An annual sampled catch-at-size data matrix (1995-1998), required for catch curve methods used to estimate annual total mortality (Z), and the selectivity ogive, was also developed using SPSS' cross-tabulations procedure (fork length data in rows, and each year in a separate column). This matrix was then exported into EXCEL where the data were aggregated by 5-cm length intervals. The annual sampled catch-at-size data were raised to reflect annual total catch-at-size data using a raising factor equal to the total catch in the western Atlantic divided by the total catch sampled from the 5 islands. Total catches for the western Atlantic were obtained from ICCAT and FAO statistical records, and in some cases directly from national fisheries offices. The annual total catch-at-size data matrix was used for input into length-based cohort analysis.

Statistical analyses

A number of factors may affect the level of catch achieved per trip and the size of fish being landed. The degree to which these variables are being influenced by country, gear type, target fishery, month, and year, was investigated using Generalised Linear Models (GLMs). The length of fishing trip (days out) was included as a covariate in the models examining mean weight of catch. Both the untransformed and natural log-transformed variables were tested.

In one model of log-transformed weight, country and target fishery were found to be significant ($F_{4,\ 10215} = 4.0$ and $F_{4,\ 10215} = 12.8$ respectively; $P \leq 0.05$). Gear type was not significant. There was no apparent pattern among countries with regard to catch (figure 2), but the mean ln (catch) was higher for the offshore pelagic fishery ('OP'), compared with the nearshore fisheries (figure 3).

A second GLM examining time factor effects and using the natural log of mean catch as the variable, confirmed the significance of the country effect in addition to a month effect ($F_{4,\ 10045} = 21.7$ and $F_{11,\ 10045} = 3.8$ respectively; $P \leq 0.05$). The following interactions were also found to be significant: country*month; country*year; country*month*year. Further investigations of the fisheries are necessary to determine the cause and extent of these significant effects. The plot of mean ln(catch) versus month (figure 4) suggests a cyclical trend towards smaller catches between July and December, with peak catches in the February to June period.

Similar GLMs of fish length showed significant effects for source country and target fishery ($F_{4,\ 11807} = 72.5$ and $F_{11,\ 11807} = 14.6$ respectively; $P \leq 0.05$), and a significant interaction between gear type and country ($F_{2,\ 11807} = 9.3$; $P \leq 0.05$). Figure 5 suggests a trend towards decreasing mean fish length for islands in the north. Figure 6 illustrates the relationship between fish length and target fishery. Generally, wahoo captured by the offshore fishery tend to have little variability in mean size (length). In comparison, those captured in nearshore areas by the other types of fisheries tend to show higher variability in size; note, however, that sample sizes from the 'mixed', 'reef' and 'slope' fisheries were small (< 15).

In the GLMs investigating time factor effects on fish length, month was found to have a significant effect (F2, 10706 = 49.1; $P \leq 0.05$), as well as all the interactions effects included in the model: country*month; country*year; month*year; country*month*year. The relationship between mean fish length and month (figure 7) essentially mirrors that of mean catch weight and month (cf figure 4), and might be indicative of the absence of larger fish during the latter part of the year, possibly due to migration beyond the Eastern Caribbean region, or the increased abundance of smaller wahoo during this same period.

Assessment analyses

Estimation of Growth Parameters - The catch data were not corrected for selectivity prior to doing Modal Progression Analysis (MPA) for the current assessment. This will have to be done prior to future revisions. MPA was used to estimate the maximum length (L_∞) and the growth coefficient (K) (Sparre *et al.*, 1992). Each sample was examined for the occurrence of modes using the Bhattacharya routine. Samples were also processed using the NORMSEP routine, but the results were almost identical to those generated by the Bhattacharya method. A total of 30 monthly samples were examined. Two samples were rejected owing to very poor data, and 31 growth modes were identified from the remaining 28 samples The results of the MPA, i.e. the 31 means identified together with estimates of their standard deviations, were stored in a special FISAT file (*.MSD file), which was then used to run the FISAT Linking Of Means (LOM) procedure. The LOM procedure was used to identify cohorts within the sample, and to follow their growth through the time period observed. The procedure gave estimates of L_∞ and K generated from a Gulland and Holt plot implied by the points selected to comprise the link of means within each cohort identified. Three attempts to identify linked cohort means from the dataset yielded the following combinations of L_∞ and K estimates: L_∞ = 203.5 cm, K = 0.47 y^{-1}, r = -0.38; L_∞ = 204.75, K = 0.47 y^{-1} and r = -0.37; L_∞ = 210.94 cm, K = 0.49 y^{-1} and r = -0.32. Given the similarity of the results of the first two fits, the results of the first fit (i.e., L_∞ = 203.5 cm, K = 0.47 y^{-1}) with the higher r value, were adopted for subsequent analyses. In addition, we also noted separately the coordinates of the 9 pairs of points giving the 'best' LOM fit, and adopted these points to undertake a Gulland and Holt plot independently using EXCEL (figure 8). By this means, we were able to observe the pattern of the points, determine outliers, and consider a further refinement of the regression fit. In the case of wahoo, no outlier points were identified in the independent Gulland and Holt plot, and so the FISAT results were retained unadjusted.

<u>Estimation of mortalities</u> - An estimate of total mortality (Z) was obtained from a linearised length converted catch curve generated using our estimated values of L_∞ and K. Catch curves were also produced using 1996 and 1997 data separately, giving estimates of: Z (1996) = 5.41 y^{-1} [4.59, 6.22], regression fit r^2 = 0.97; and Z (1997) = 4.58 y^{-1} [4.10, 5.06], regression fit r^2 =0.98 respectively. To obtain an annual average estimate of Z, the sample data were added for the years 1996-1998 and then divided by 2.5, because 1998 was considered a half year for sampling. The points selected for the regression fit included the range 105 cm to 155 cm (figure 9a), and Z was estimated to be 4.612 y^{-1}, regression r^2 =0.96, 95% C. I. = [3.85, 5.36] (figure 9b). Given the implicit assumption of a constant Z over all length intervals, the annual average estimate of Z (=4.612 y^{-1}) was used in subsequent analyses. Using Pauly's formula, and assuming an average sea surface temperature of 27.5 ^{0}C, M was estimated to be 0.63 y^{-1}. In consequence, average fishing mortality was 3.98 y^{-1}.

<u>Estimation of selectivity</u> - Length at first capture (L_c), i.e. the length at which 50% of the fish are caught by the gear, was estimated using the catch curve method, and hence assuming a sigmoid-type selection ogive (figure 10). This was considered to be acceptable for this first assessment for the following reason. A range of hook sizes is used in the fishery, and so it may be safe to assume that once a fish reaches a certain size, its probability of being caught is equal to 1 when it encounters the gear. The estimated selectivity curve was also used to re-confirm the choice of points included in the catch curve regression fit for calculating Z. Using Z = 4.612 and the corresponding intercept value of 15.35 acquired from catch curve analysis, estimated L_c = 90.4 cm, with a 95% C.I. of [85.6 cm, 95.4 cm].

<u>Cohort Analysis and Yield and Biomass Prediction</u> - This analysis may not appropriate to apply to the Eastern Caribbean data, given that the Eastern Caribbean catch represents only about 20% of the total western Atlantic catch, and the average annual sampling coverage rate was generally low, ranging from 3% to 22% (Table 1). Jones' length based cohort analysis (Jones, 1981) was set up in an EXCEL spreadsheet and applied to the average annual total catch-at-size data matrix, using the input parameters K, L∞, M, and F/Z that we generated from our own data. F/Z was calculated from the relationship Z=F+M, and substituting for Z (from catch curve analysis) and M (Pauly formula). Results of the cohort analysis are given in table 2. The cohort generated F–

at-size matrix and the population size of the first length group were then input into a Thompson and Bell Yield and Biomass prediction analysis (Sparre *et al.*, 1989).

Also required as input, the average weight-at-size data matrix was developed using George's length –weight equation for wahoo:

$$\text{Weight (kg)} = 4.06\text{E-06} * (\text{fork length in cm})^{3.028}$$

The model predicted yield and biomass for different levels of fishing mortality. Assuming one stock for the Western Atlantic, MSY was estimated to be 2,137 mt, with F_{MSY} estimated to be 0.34 y^{-1} (figure 11). This result suggests that wahoo is over-exploited, and that current fishing mortality is about three times higher than the optimum desired level. Use of the more conservative reference point $F_{0.1}$ would necessitate an even further reduction in present levels of fishing mortality. Assuming a constant price of EC$15.60/kg for all sizes of wahoo, the estimated maximum value occurred at US$ 12,242,984.00, with a corresponding F =0.34 y^{-1}.

<u>Yield Per Recruit (YPR) / Biomass Per Recruit (BPR)</u> – The length based model of Beverton and Holt (Sparre et al., 1989) was set up in an EXCEL spreadsheet and applied, assuming knife-edge selectivity at L_c=90 cm. Four other values of L_c, ranging from 50 cm to 100 cm, were also examined with the model. Our estimates of L_∞, K, M, 'a' and 'b' from George's length-weight relationship (i.e. W = a.[fork length]^b) and hence W_∞, were used for input into this model. Length at recruitment to the fishery (L_r) was arbitrarily set at 15 cm. Maximum YPR was estimated to occur at an F value of 1.09 y^{-1}, almost 4 times lower than the current F of 3.98 y^{-1} (figure 12a). The estimated value of $F_{0.1}$ was 0.37 y^{-1}. Sensitivity of YPR to variation in M was examined for Lc =90 cm (figure 12b). The maximum in the YPR curve was better defined at a smaller M, with a corresponding smaller F_{msypr}. In the case of a value of 1.5*M, the YPR curve had no distinct maximum. The F values, that are expected to maintain the stock at 30% and 40% of its initial BPR level, were 0.68 y^{-1} and 0.47 y^{-1} respectively (figure 13a). Sensitivity of BPR to different values of M were also examined for L_c =90 cm (figure 13b), and as may be expected, the sensitivity was greater at lower levels of F. As observed for the Thompson and Bell predictive model, the results of the YPR/BPR analysis imply that wahoo is over-exploited and that the current fishing mortality level is not sustainable.

Recommendations

As noted for dolphinfish, there is some concern about the low sampling coverage rate, and incompleteness of the dataset given the possibility of a total western Atlantic stock. The results of these assessments must be interpreted with caution at this time. There were no apparent annual trends in mean catch rates (i.e., catch per days out). Similarly, mean fish size fluctuated with no definite trend. Given the uncertainty in the estimates of the basic stock parameters, greater emphasis was placed on the trend analyses for development of management recommendations at this time. Specific recommendations follow.

Management recommendations:

Noting the absence of any real trends in catch rates and mean fish size since 1995, which imply that the wahoo fishery in the Eastern Caribbean appears to be stable at current levels of fishing effort,

Considering, however, the potentially wide distribution of the wahoo fishery, possibly extending to the whole western Atlantic Ocean, and the subsequent limitations in using only the Eastern Caribbean dataset for determining the status of the stock, it is recommended that

1) Wahoo fisheries should be expanded cautiously, if at all;
2) A broader regional assessment should be undertaken in the very near future, to improve our estimates of the basic stock parameters so as to generate better informed management recommendations for this fishery;
3) A regional Working Group should be established to address the assessment of highly migratory species such as wahoo and dolphinfish. Ideally, this Working Group should co-ordinate its activities under the aegis of the FAO WECAFC, in partnership with relevant sub-regional agencies.
4) Detailed assessments be undertaken on a regular basis to provide timely information on the status of wahoo stocks and appropriate management advice.

Data and research recommendations:

Acknowledging that significant progress has been made under the CFRAMP programme in the collection and analyses of fisheries and biological data,

Noting the significant achievements of the current joint assessment undertaken by CFRAMP countries at the level of the Eastern Caribbean,

Noting also the importance of the wahoo fisheries to national and regional economies,

Recognising the need to examine data from a wider area of distribution of the stock, it is recommended that

1) CFRAMP/CRFM countries should strive to maintain and improve their national data collection programmes, and sampling coverage rates for wahoo;
2) Mechanisms should be put in place to ensure that appropriate and detailed effort information is obtained on regular basis for the fishery, to allow for more accurate interpretation of catch and biological data (e.g. use of log books by fishers; annual effort surveys);
3) Sampling programmes should be expanded to include capture of data from the existing sport and longline fisheries, which harvest size ranges of wahoo that are different from those of the commercial fisheries;

4) CFRAMP, and subsequently the CRFM, should make every effort to continue to support the collection and analysis of good catch and effort and biological data at the country level, and to facilitate regular regional assessment of shared stocks;
5) Future regional assessments should include data from other countries which share the resource and which harvest substantial amounts of wahoo;
6) Future regional assessments should take into account the effects of gear selectivity;
7) Future regional assessments should include analyses incorporating social and economic information on the fishery;
8) The results of the CFRAMP/IMA wahoo age and growth study, particularly the value obtained for the growth constant ‘K’, should be considered in future assessments;
9) The CFRAMP fish tagging program should continue, as these studies yield valuable information on stock distribution, migration, as well as growth and mortality rates, useful for assessment and management purposes;
10) Other studies, such as the UWI/MAREMP genetic study of wahoo should continue, as these studies yield valuable information on stock identification, useful for assessment and management purposes.
11) CFRAMP, and subsequently the CRFM, should review the existing database, and identify information gaps for development of pertinent research projects.

Table 1. Annual total catches (kg) of wahoo reported for the period 1996-1998

Country	1996	1997	1998	Annual average	Source
Barbados	49163	47167	47426	47918.67	FD
Grenada	55880	55909	59453	57080.67	FD
St. Lucia	221000	195279	243833	220037.3	FD
St. Vincent	22755	910	16500	13388.33	FD
Dominica	59000	59000	59000	59000	FD
Venezuela	479000	479000	479000	479000	ICCAT
Aruba	50000	50000	50000	50000	ICCAT
USA	608000	749000	679000	678666.7	ICCAT
N. Antilles	230000	230000	230000	230000	ICCAT
Brazil	16000	58000	37000	37000	ICCAT
Bermuda	115000	103000	109000	109000	ICCAT
Total	**1905798**	**2027265**	**2010212**	**1981092**	

Table 2. Results of Cohort Analysis assuming one stock for the Western Atlantic.

Lower limit of length interval (cm)	X(L1,L2)	No. caught, C(L1,L2)	Nos. in the sea attaining length, N(L1)	F/Z	F	Z	Average nos. in the sea, N(L1,L2)
25.0	1.01930596	117	887131.0	0.0035	0.0022	0.63	52610.1
30.0	1.01987612	273	853729.4	0.0082	0.0052	0.64	52076.0
35.0	1.02048098	390	820509.7	0.0118	0.0076	0.64	51523.0
40.0	1.02112381	819	787522.9	0.0248	0.0161	0.65	50941.2
45.0	1.02180830	1287	754475.2	0.0389	0.0256	0.66	50317.5
50.0	1.02253864	1482	721354.0	0.0450	0.0298	0.66	49657.9
55.0	1.02331959	2809	688455.2	0.0832	0.0574	0.69	48929.1
60.0	1.02415661	5890	654690.4	0.1624	0.1227	0.76	48020.6
65.0	1.02505595	9089	618419.4	0.2347	0.1940	0.83	46851.0
70.0	1.02602486	16188	579689.4	0.3612	0.3578	0.99	45243.2
75.0	1.02707172	25082	534877.6	0.4801	0.5842	1.22	42935.9
80.0	1.02820633	31830	482631.6	0.5577	0.7977	1.43	39899.9
85.0	1.02944023	52543	425558.3	0.7003	1.4781	2.11	35547.7
90.0	1.03078702	56872	350525.5	0.7503	1.9010	2.53	29916.8
95.0	1.03226296	73606	274726.2	0.8344	3.1887	3.82	23083.3
100.0	1.03388755	61007	186516.2	0.8588	3.8494	4.48	15848.5
105.0	1.03568445	45794	115482.4	0.8800	4.6408	5.27	9867.7
110.0	1.03768261	30113	63445.4	0.8977	5.5532	6.19	5422.7

115.0	1.03991786	14511	29901.7	0.8954	5.4178	6.05	2678.4
120.0	1.04243505	5539	13696.2	0.8647	4.0424	4.68	1370.2
125.0	1.04529115	2184	7290.3	0.8067	2.6397	3.27	827.4
130.0	1.04855954	1677	4582.8	0.8327	3.1485	3.78	532.6
135.0	1.05233646	663	2568.9	0.7541	1.9402	2.57	341.7
140.0	1.05675067	468	1689.7	0.7555	1.9547	2.59	239.4
145.0	1.06197836	390	1070.2	0.7983	2.5047	3.14	155.7
150.0	1.06826734	156	581.7	0.7156	1.5919	2.22	98.0
155.0	1.07597750	0	363.7	0.0000	0.0000	0.63	78.3
160.0	1.08565227	78	314.1	0.6530	1.1903	1.82	65.5
165.0	1.09815291	78	194.7	0.7480	1.8783	2.51	41.5
170.0	-	78	90.4	0.8628	3.9793	4.61	19.6

Figure 1. Total reported annual landings (mt) of wahoo in five Eastern Caribbean countries for the period 1991-1998.

Figure 2. Estimated mean ln(catch) for 5 eastern Caribbean countries, with 95% confidence limits shown.

Figure 4. Monthly changes in mean ln(catch) of wahoo for the period 1994 to 1999, adjusted to daysout=1.08, and with 95% confidence limits shown by dotted lines.

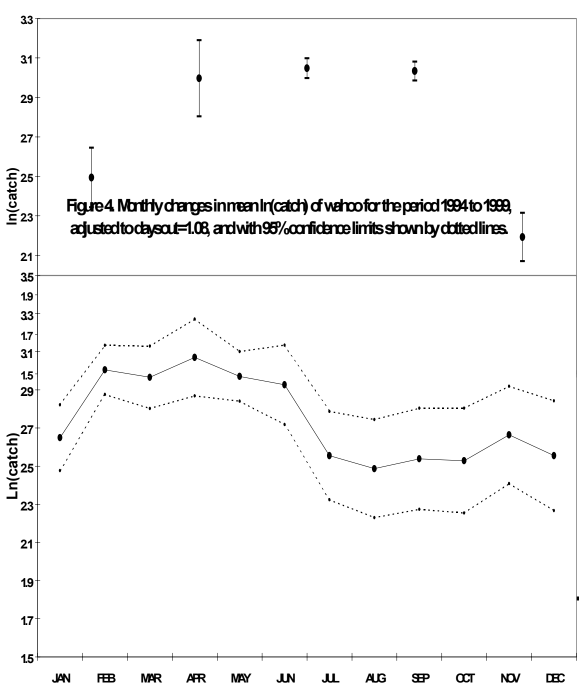


Figure 3. Estimated mean ln(catch) of wahoo by different types of fishery, with 95% confidence limits shown.

Figure 5. Annual mean ln(catch) of wahoo for the period 1994 to 1999, adjusted to daysout=1.08 and with 95% confidence range shown by dotted lines.

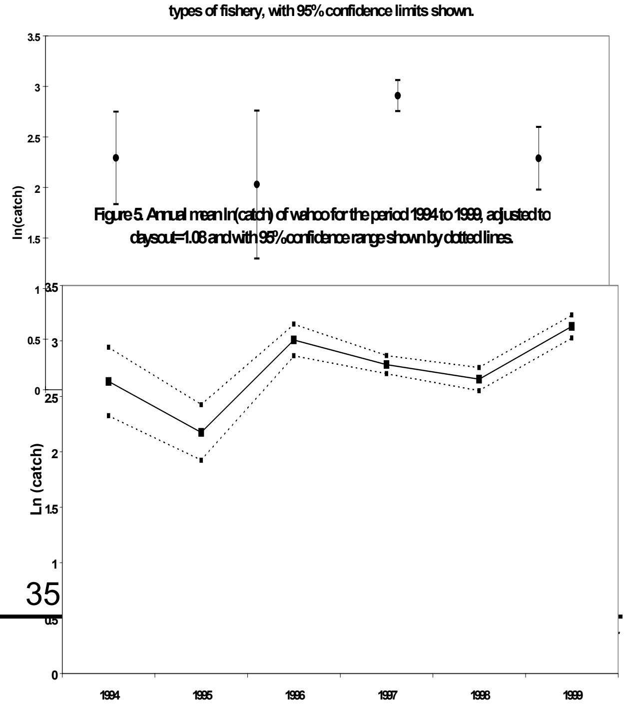


Figure 6. Estimated mean length of fish caught by 5 eastern Caribbean countries, with 95% confidence limits shown.

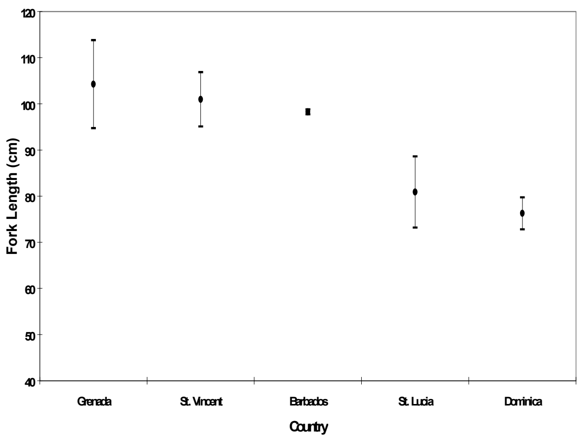


Figure 7. Estimated mean length of fish caught by different fisheries, with 95% confidence limits shown.

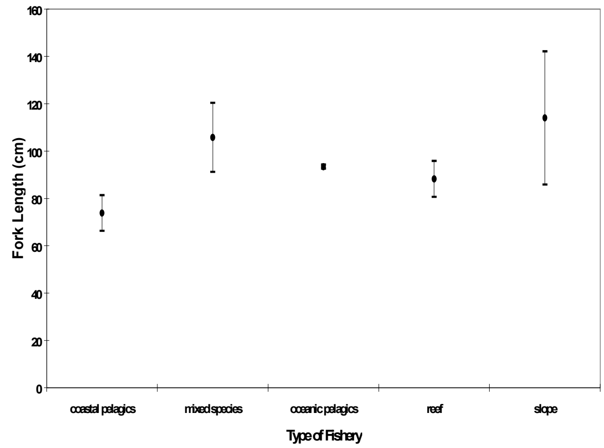


Figure 8. Monthly changes in estimated mean length (cm) of fish caught, with 95% confidence interval indicated by dotted lines.

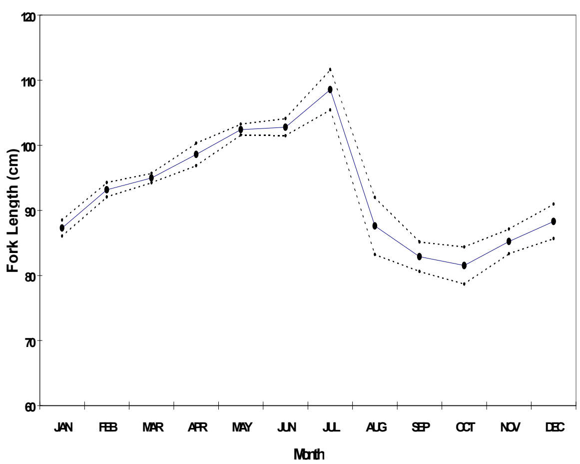


Figure 9. Estimated annual mean fork length of wahoo caught, with 95% confidence interval indicated by dotted lines.

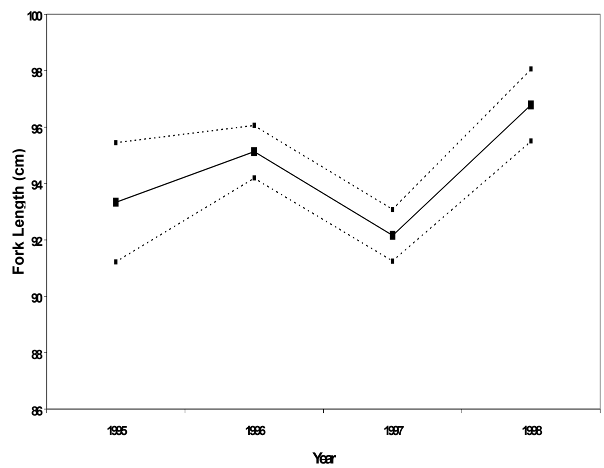


Figure 10. Gulland and Holt Plot for Wahoo

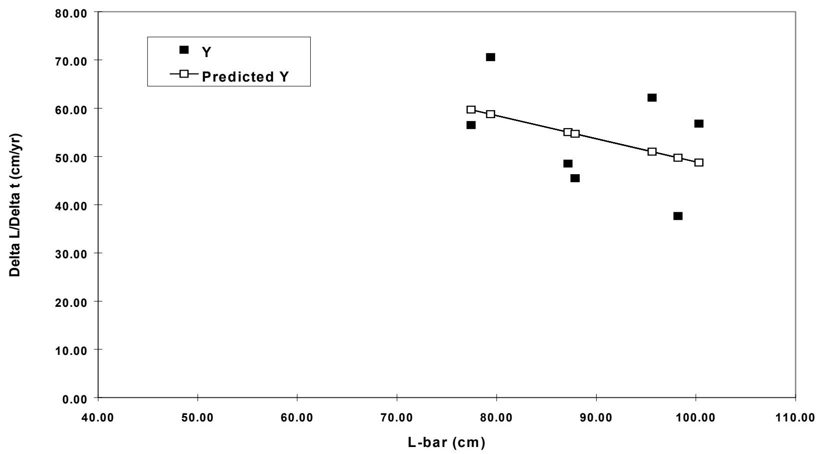


Figure 11a. Catch Curve for wahoo

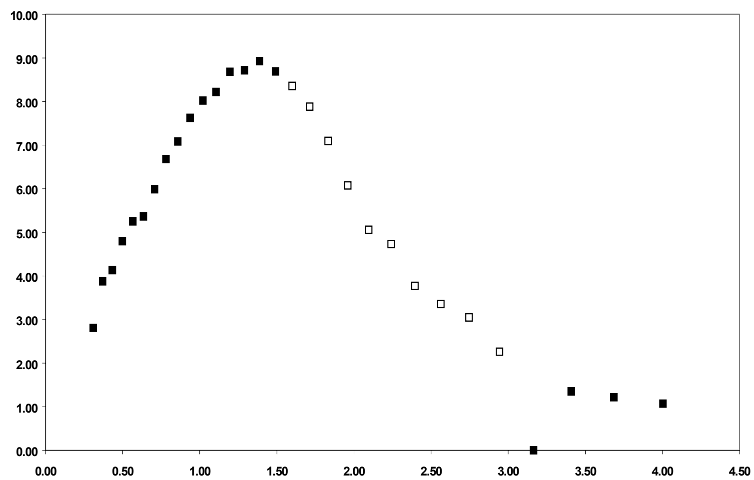


Figure 11b. Catch curve regression fit for wahoo, using L-infinity of 203.5, and K=0.47

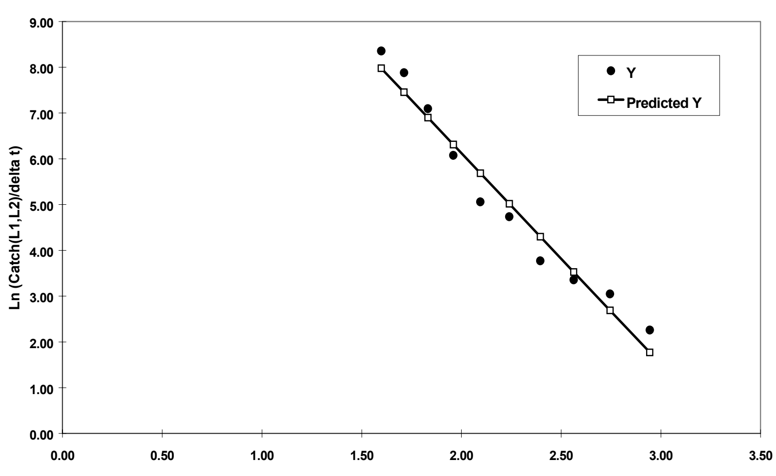


Figure 12. Selectivity Curve (S (t)) for wahoo

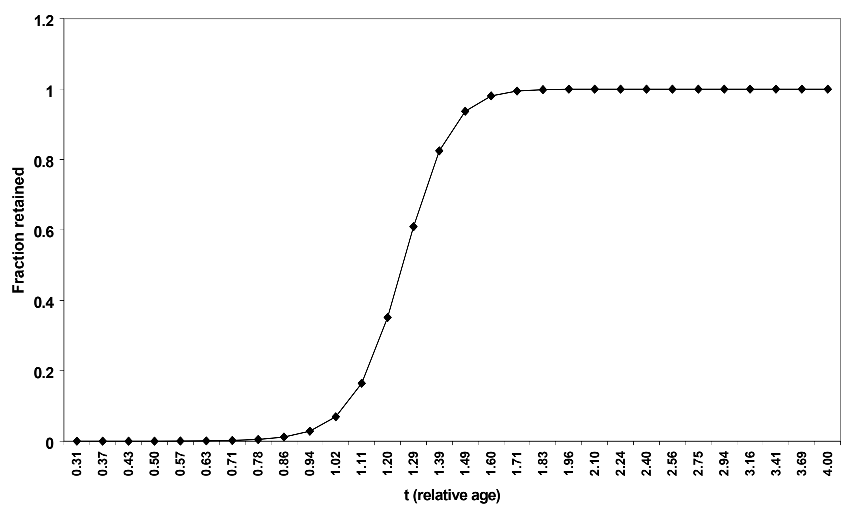


Figure 13. Yield (kg), mean biomass (kg) and value (US$) prediction curve for wahoo

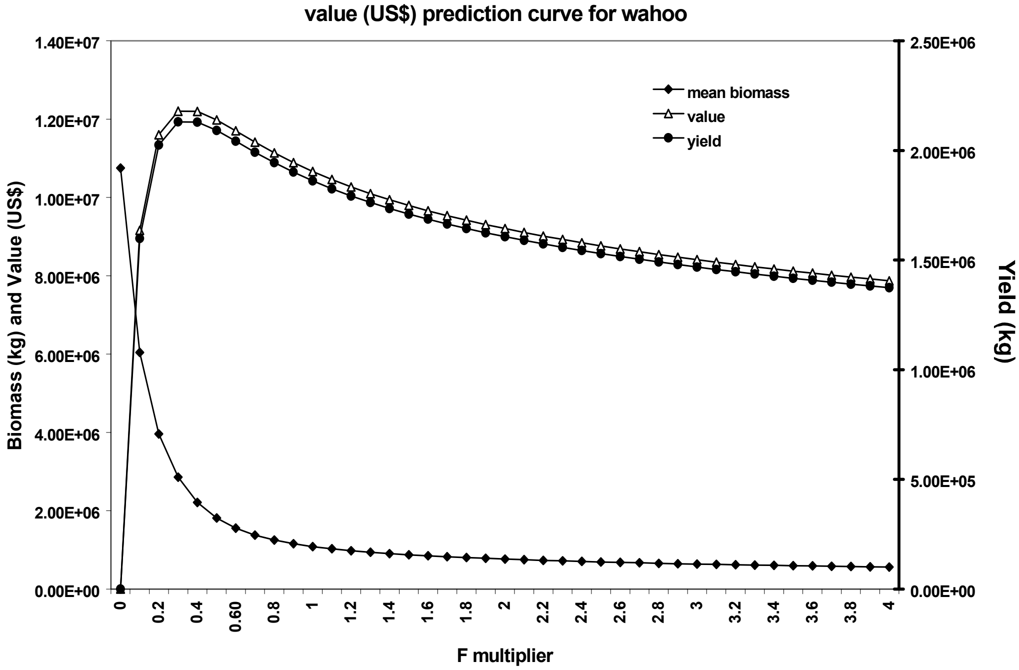


Figure 14a. YPR (kg) for different lengths at first capture for Wahoo

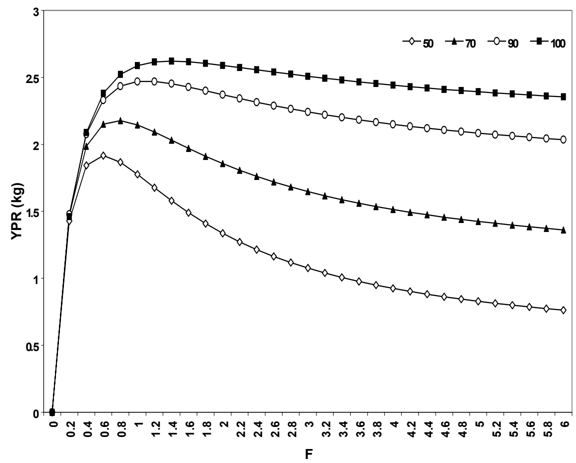


Figure 14b. Sensitivity of Wahoo YPR to estimated M

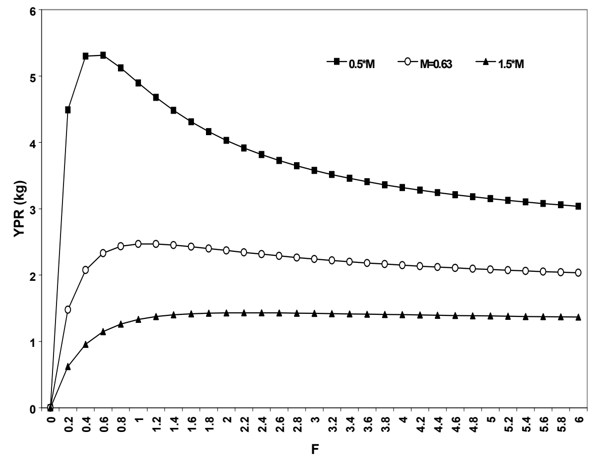


Figure 15a. BPR (kg) for different lengths at first capture for Wahoo

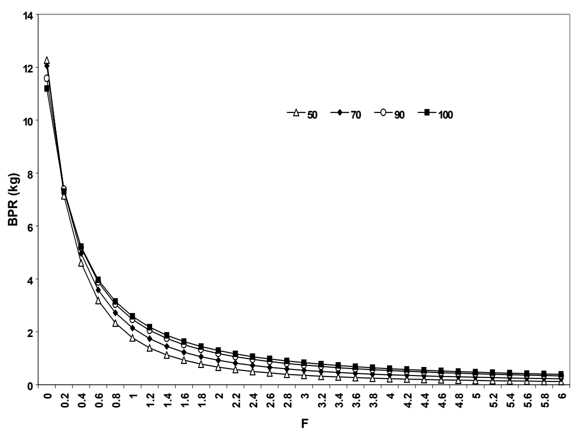
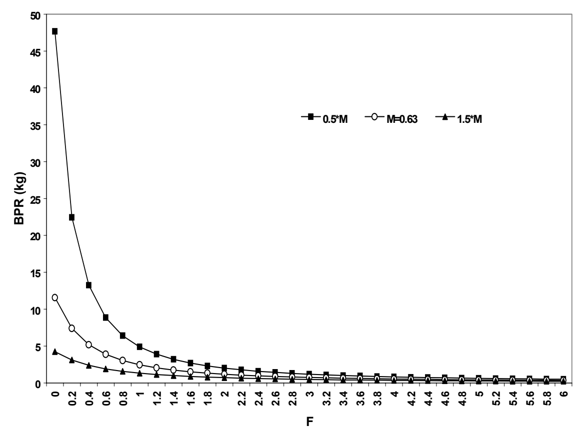


Figure 15b. Sensitivity of Wahoo BPR to estimated M



Working Document: CFRAMP_PRFA/2000-05

Assessment of Dolphinfish (*Coryphaena hippurus*) Fishery Using Eastern Caribbean Data

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Introduction

The common dolphinfish *Coryphaena hippurus* is distributed worldwide, inhabiting tropical and subtropical surface oceanic waters. In the Atlantic ocean, dolphinfish are most commonly found as far north as North Carolina, throughout the Caribbean, Gulf of Mexico and as far south as the North coast of Brazil (Oxenford, 1999). Throughout its geographic range, dolphinfish is targeted by both commercial and recreational fishers. Within the Eastern Caribbean, dolphinfish constitutes a very substantial portion of total offshore pelagic catches.

The most common gear used in the Eastern Caribbean is the hook and line, and may be captured by fishermen operating from all types of motorised fishing vessel found in the region, including canoes, dinghies (referred to as "Moses" in Barbados), pirogues, the day-launches and iceboats of Barbados (See CFRAMP_PRFA / 2000-13) longliners and cabin cruisers. Hook and line assemblies also vary, ranging from the most basic design of hand held hook on nylon line, trolling hook and line, rod and reel used mainly by the recreational fishers, vertical and horizontal long line arrangements. Throughout the region, both dolphinfish and wahoo are captured using similar gear specifications, e.g. hook size and line strengths (see CFRAMP_PFRA / 2000-04 and CFRAMP_ PRFA / 2000-13 for more details).

Fishing site indicators are also basically the same for dolphinfish and wahoo, for example the presence of seabirds and flotsam. While Barbadian fishers usually fish for the large pelagics such as dolphinfish and wahoo, in tandem with gill net fishing for flying fish, fishers from most of the other islands focus their efforts almost exclusively on capturing the larger pelagics, taking flying fish only incidentally and mainly for use as bait. In the Eastern Caribbean, fishing trips of the more artisanal operations usually range in length from 8-12 hours, while fishing trips of Barbadian iceboats are usually around 10 days in duration, inclusive of travel and search times.

The fishing fleet capacity of most of the islands in the region has increased mostly over the last decade. Both the number and size of vessels have increased, as described in working documents CRAMP_PRFA / 2000-04 and CFRAMP_PRFA / 2000-13.

A trend in increasing catches of dolphinfish has been reported throughout the western-central Atlantic region over the last 3 decades, increasing from around 1700 mt in 1970-1974 to around 2800 mt in 1989-1993 (Mahon, 1999). Barbadian fishers record the largest total dolphinfish landings in the Eastern Caribbean (Figure 1). Within the Eastern Caribbean, the majority of dolphinfish are taken during the first half of the year (Figure 2).

Preparation of data for analysis

As in the case of wahoo, monthly sample sizes were too low (< 80 fish sampled) for most months in 1995, but were reasonable in 1996-1997 and the first half of 1998. In Barbados, St. Vincent and the Grenadines, and Grenada, catch data were recorded in gutted weight, with round weights recorded in St. Lucia and in Dominica. During February 1999, St. Lucian fisheries staff collected data on round weight, gutted weight, fork length, and sex from a sample of 52 dolphinfish (George, pers comm). These data were used to determine equations describing the relationships between round and gutted weight, and between fork length and round weight. Given the small sample size, these relationships may have to be improved with additional sampling in the near future. The St. Lucian length-weight conversion equation (George's dolphinfish equation) was adopted for the current assessment.

Barbados did not record the weight of dolphinfish landings sampled for lengths. Hence, in the case of Barbados, the individual sampled fish weights were reconstructed using George's dolphinfish equation.

The monthly sampled catch-at-size data matrix (1995 to 1998), required for input into FISAT for Modal Progression Analysis (MPA), was developed using SPSS' cross-tabulations procedure (fork length data in rows, and each month in a separate column). This matrix was then exported into EXCEL where the data were aggregated by 5-cm length intervals and the layout edited for direct import into FISAT. Given that the included sampled dolphinfish lengths ranged from 21 cm to 192 cm, and the FISAT upper limit of 50 length intervals, a length interval of 4-cm or greater had to be used. Given the perceived fast growth rate of dolphinfish, we decided to use length intervals of 5-cm for the current assessment, as it was easier to work with, and any improvement to MPA by reduction to 4-cm intervals may have been negligible for the dolphinfish case. Notwithstanding, it may be useful to redo the MPA using 4-cm intervals to confirm this statement.

As described for wahoo, an average annual sampled catch-at-size data matrix was developed using data for the period 1996-1998. The data were aggregated by 5-cm length intervals. The Oxenford hypothesis of a separate Eastern Caribbean stock was adopted as the working hypothesis for the current assessment. The average annual sampled catch-at-size data were therefore raised to reflect an average annual totals using a raising factor equal to the total Eastern Caribbean catch divided by the total catch sampled from the 5 islands.

Statistical analyses

During the time period studies, dolphinfish were captured with five types of fishing gear: handline, trolling line, vertical longline, bottom longline, and "palangue" (surface longline). The majority of dolphinfish were captured with either handline (84%) or trolling gear (15%). Less than (1%) of the catches were taken by each of the other types of fishing gear. The largest mean catch of dolphinfish taken per vessel was recorded by Barbados (186.9 kg) with the mean catches reported for vessels from the other islands being substantially lower; Dominica (32.2 kg), Grenada (45.3 kg), St. Lucia (42 kg), and St. Vincent and the Grenadines (47.2 kg).

General Linear Model analyses were used to determine changes in weight and size of dolphinfish caught with changes in area (i.e. island differences), and through time (month, and year). The length of fishing trip was included as a covariate in the model of catch weight.

The GLM indicated that of the three factors (island, month and year), only month had a significant effect on the mean weight of landings ($F_{11,\ 26218)} = 4.224$; p= <0.05). However, GLM analyses on the log transformed data indicated significant effects of all three factors on the mean landings weight.

Another GLM analysis indicated that fish sizes were significantly affected by all of the three factors: island, month and year ($F_{4/17698} = 53.86$, $F_{4/17698} = 77.58$, $F_{4/17698} = 55.19$ respectively; all $p<0.05$). Plots of these effects are presented respectively in figures 3-5. Factor interaction effects were also significant.

Figure 3 indicates that fish sizes tend to decrease towards the northern islands. This may be indicative of a distinct stock structure, or removal of larger fish from the stock by fishers in the southern most islands while the fish are migrating on a northern track.

Figure 4 indicates that fish sizes gradually increase over the first five months of the year. The increase is followed by a comparatively sharp decrease from the month June reaching a minimum in September. The sizes of the fish then gradually increase again over the last the 4 months of the year. This pattern suggests that recruitment to the fishery may occur during these summer months.

Figure 5 shows a gradual decrease in the mean size of fish during the first three years followed by a sharp increase in size in 1998. There is insufficient information to explain this trend accurately, but it may be related to changing environmental conditions. In 1998, the occurrence of El Niño may have enhanced the growth of the fish in that year at least.

Assessment analyses

Estimation of growth parameters, L_∞ and K – A von Bertalanffy growth pattern was assumed. The two growth parameters, L_∞ and K were estimated by the method of Modal Progression Analysis using FISAT software (Gayanilo *et al.*, 1996). It should be noted that the length frequency data were not adjusted for gear selectivity prior to MPA analyses. A LOTUS file containing 44 months of sample data was prepared and imported into FISAT. Of 36 samples processed using the Bhattacharya, followed by the NORMSEP routine, a total of 76 possible means were identified. These means were then examined using FISAT's LOM procedure, and the progression of the growth modes of three cohorts was apparent. Those means which followed closely the observed patterns of cohort growth were then linked, yielding the following growth parameter estimates: $L\infty = 199.4$, and $K=0.56$. The means selected for linkage, produced 9 pairs of points (i.e., length at t, length at t + delta t) which were then used to reconstruct the Gulland and Holt plot, within EXCEL (Figure 6). This scatterplot showed no obvious outliers, and the expected linear relationship between the y variable (delta L/delta t) and the x variable (L-bar) was apparent. It should be noted that delta t (time difference) between the elements of each pair of points ranged from 3 to 5 months. Observed lengths of the selected points ranged from 42.5 cm to 124.6 cm. The fitted regression model explained 53% of the variation (r^2=0.53). A plot of the residuals showed no particular pattern, although 2 large residuals were observed. Additionally, the standard error of the intercept was large (=18.07), with the standard error of the slope being 0.19. It may be possible to improve the fit through alternative LOM fits of the current data following correction for gear selectivity, and/or through further improvement to the dataset. For the current assessment, the FISAT LOM estimates were adopted as they gave the best 'eye' fit of the observed growth mode progression patterns.

<u>Estimation of annual total, natural and fishing mortality estimates</u> – An estimate of the total mortality rate, Z, was obtained by constructing a linearised length converted catch curve. This method assumes a von Bertalanffy growth pattern for conversion of lengths to relative ages, and assumes that Z is constant over all ages. As in the case of wahoo, an average annual sampled catch-at-size data matrix (1996 to 1998 data, divided by 2.5 because 1998 was considered a half year for sampling) was used for this analysis, in order to minimise any violation of the assumption of a constant parameter system. Figure 7a shows the catch curve and selected points for the linear regression fit with slope equal to –Z. Two regression fits were attempted using: (i) points corresponding to the length range 110-170 cm, and (ii) points corresponding to the length range of 100-160 cm. In both regressions, the zero value for the length interval 145-150 cm was an obvious outlier and was omitted from the fits. The regression fit for (i) yielded a Z of 4.84 y^{-1}, with 95% C. I. [3.475, 5.493] and r^2=0.89. In the case of (ii), r^2 was 0.95, and Z was estimated to be 5.98 y^{-1}, with 95% C. I. =[4.85, 7.10]. In both instances, plots of the residuals showed some pattern, implying less than perfect and unbiased fits. Data points for lengths larger than 160 cm showed notable deviation from the linear pattern, probably due to small sample sizes and/or that they may not be under full exploitation by the fisheries included in the assessment. Fit (ii) was therefore adopted as these points showed a clear linear pattern, associated with full exploitation and the assumption of a constant Z over the length range observed (Figure 7b).

Natural mortality (M) was calculated using Pauly's formula, and inserting the estimates for L_∞, and K generated from our MPA. The average sea surface temperature was assumed to be 27.5 ^{0}C. M was estimated to be 0.71 y^{-1}. Assuming Z to be 5.98 y^{-1}, and M to be 0.71 y^{-1}, the average fishing mortality (F) was calculated to be F = Z-M = 5.27 y^{-1}.

<u>Estimation of selectivity</u> – Selectivity was assumed to follow a sigmoid-type pattern. This may be a reasonable assumption given that dolphinfish are caught by a variety of hook sizes in the various islands. Consequently, the selectivity curve was estimated by extension of the length-converted catch curve method, using as input the slope and intercept of the adopted catch curve regression fit, i.e. slope = Z = 5.98, and intercept = 17.269. Length at first capture (L_c), i.e. the length at which 50% of the fish are caught by the gear, was estimated to be 98.9 cm (95% C.I. = [93.5, 104.6]). It may be of interest to note that when the input values from catch curve regression fit (i) were used (i.e. Z = 4.484 and corresponding intercept value of 14.639), L_c was estimated to be 91.8 cm.

Cohort Analysis – Data on available reported landings of dolphinfish in the West Atlantic were compiled from various sources (Table 1). Assuming the occurrence of a separate dolphinfish stock in the Eastern Caribbean for the current preliminary analysis, Jones' length based cohort analysis was applied to the average annual total catch-at-size data matrix, using the input parameters K, $L\infty$, M, and F/Z that we generated from our own data. F/Z was calculated from the relationship Z=F+M, and substituting for Z (from catch curve analysis) and M (Pauly formula). Results of the cohort analysis are given in table 2. Fishing mortality tended to increase with increase in fish size, with maximum mortality observed for the length range 110-115 cm.

Yield and Biomass Prediction – Following completion of Jones' length cohort analysis, the Thompson and Bell predictive length based model (Sparre *et al.*, 1992) was set up in an EXCEL spreadsheet. Input data for this model were obtained from the results of our cohort analysis. Also required as input, the average weight-at-size data matrix was developed using George's equation. The model predicted yield and biomass for different levels of fishing mortality. Assuming one stock for the Eastern Caribbean, MSY was estimated to be 2,917 mt, with F_{MSY} estimated to be 0.57 (Figure 8). These results imply that dolphinfish may be over-exploited, and that current fishing mortality is higher than the optimum desired level. Use of the more conservative reference point $F_{0.1}$ would imply an even further reduction in present levels of fishing mortality. Assuming a constant price of EC$15.60/kg for all sizes of dolphinfish, the estimated maximum value occurred at US$ 16,711,952.00, with a corresponding F =0.57.

Yield Per Recruit (YPR) / Biomass Per Recruit (BPR) – The length based model of Beverton and Holt (Sparre et al., 1989) was set up in an EXCEL spreadsheet and applied, assuming knife-edge selectivity at L_c=99 cm, as well as four other values of L_c, ranging from 50 cm to 110 cm.. Our estimates of L_∞, K, M, 'a' and 'b' from George's length-weight relationship (i.e. W = a.[fork length]^b) and hence W_∞, were used for input into this model. Length at recruitment to the fishery (L_r) was arbitrarily set at 15 cm. Maximum YPR was estimated to occur at an F value of 1.54, approximately 3 times lower than the current F of 5.27 (Figure 9a). The F values, that are expected to maintain the stock at 30% and 40% of its initial BPR level, were 0.84 and 0.57 respectively (Figure 10a). Sensitivity of YPR and BPR to different values of M were also examined for L_c =99 cm (Figures 9b & 10b). These figures show that both YPR and BPR were sensitive to the input value for M, and that the sensitivity was greater at lower levels of F. As observed for the Thompson and Bell predictive model, the results of the YPR/BPR analysis imply that dolpinfish is over-exploited and that the current fishing mortality is not sustainable.

Recommendations

Management recommendations:

Noting the absence of any real trends in catch rates and mean fish size since 1995, which imply that the dolphinfish fishery in the Eastern Caribbean appears to be stable at current levels of fishing effort, no management recommendations are put forward at this time.

Considering, however, the potentially wide distribution of the dolphinfish fishery, possibly extending to the whole western Atlantic, and the subsequent limitations in using only the Eastern Caribbean dataset for assessment, it is recommended that

1) The assessment should be updated in the very near future, and should incorporate data from other countries with notable catches of dolphinfish.

Data and research recommendations:

Acknowledging the significant progress made under the CFRAMP programme in the collection and analyses of fisheries and biological data, and

Recognising the need to examine data from a wider area of distribution of the dolphinfish stock, it is recommended that

1) Every effort should be made to continue and expand data collection programmes, and to increase the sampling coverage rates;
2) It would be very useful to acquire more detailed data on effective effort, such as the number, types and sizes of hooks fished, number of lines fished, number of hours fished, etc. These data can be used to determine trends in catch per unit of effort (CPUE), which can be a reliable measure of species abundance.
3) Future assessments should include data from other countries which share the resource and which harvest substantial amounts of dolphinfish;
4) The results of dolphinfish age and growth studies using hard parts, particularly the value obtained for the growth constant 'K', should be considered in future assessments;
5) The CFRAMP fish tagging program should continue, as these studies yield valuable information on stock distribution, migration, as well as growth and mortality rates, useful for assessment and management purposes;
6) Other studies, such as genetic studies should be encouraged, as these studies could yield valuable information on stock identification, useful for assessment and management purposes.

Table 1. Available reported landings of dolphinfish from the W. Atlantic region for the period 1996-1998 (grey shaded rows show data used for current assessment).

COUNTRY	1996	1997	1998	ANNUAL AVERAGE	SOURCE
EASTERN CARIBBEAN AREA					
Barbados	849392.4	720910.8	487311.6	685871.6	FD
Grenada	130068.6	171375.9	151396.3	150946.9	FD
St. Lucia	309800	388519.5	258015.8	318778.4	FD
St. Vincent	72724.09	33830.4	59006.4	55186.96	FD
Dominica	84227.72	91485	103942.7	93218.48	FD

Venezuela	320090	330030	310150	320090	Jose Javier Alio, pers comm.
Aruba	0	0	0	0	
N. Antilles	0	0	0	0	
T&T	0	0	0	0	
Virgin Islands,UK	6428.571	9285.714	3571.429	6428.571	FD
Curacao	150000	150000	150000	150000	FD(estimate)
Martinique	250000	383000	344333*	316500	FAO
Guadeloupe	720000	800000	740000*	760000	FAO
Eastern Caribbean Total	**2892731**	**3078437**	**1523394**	**2498188**	
<u>WESTERN ATLANTIC</u>					
Jamaica	105000	105000	105000	105000	FD
Dominican Rep.	237000	113000	146333*	175000	FAO
USA	739000	780000*	780000*	739000	FAO
Mexico	244000	169000*	169000*	244000	FAO
Brazil	0	0	0	0	
Bermuda	3200	6650	4925	4925	
Overall total	**7113663**	**6381525**	**3156713**	**5550634**	

Table 2. Results of dolphinfish cohort analysis, assuming an Eastern Caribbean stock.

Lower limit of length interval	X(L1,L2)	No. caught, C(L1,L2)	Nos. in the sea attaining	F/Z	F	Z	Average nos. in the sea,
20.0	1.018	308	741041	0.0116	0.0084	0.72	36731
25.0	1.019	1109	714524	0.0409	0.0305	0.74	36407
30.0	1.019	1129	687436	0.0420	0.0313	0.74	36055
35.0	1.020	1396	660580	0.0520	0.0391	0.75	35687
40.0	1.021	1355	633719	0.0510	0.0384	0.75	35305
45.0	1.021	2443	607172	0.0894	0.0700	0.78	34883
50.0	1.022	6077	579838	0.1989	0.1771	0.89	34310
55.0	1.023	4866	549279	0.1685	0.1446	0.86	33649
60.0	1.024	6056	520403	0.2047	0.1837	0.90	32971
65.0	1.024	7514	490820	0.2465	0.2334	0.95	32187
70.0	1.025	8808	460339	0.2829	0.2815	1.00	31287
75.0	1.026	14351	429206	0.4004	0.4765	1.19	30115

80.0	1.028	22152	393366	0.5222	0.7797	1.49	28410
85.0	1.029	35785	350942	0.6602	1.3861	2.10	25816
90.0	1.030	39213	296736	0.7100	1.7466	2.46	22451
95.0	1.032	47651	241503	0.7834	2.5812	3.29	18461
100.0	1.033	48247	180679	0.8292	3.4638	4.18	13929
105.0	1.035	40383	122493	0.8553	4.2189	4.93	9572
110.0	1.037	30262	75280	0.8773	5.1006	5.81	5933
115.0	1.040	19627	40784	0.8949	6.0777	6.79	3229
120.0	1.042	8869	18853	0.8861	5.5538	6.27	1597
125.0	1.045	4578	8845	0.8924	5.9199	6.63	773
130.0	1.049	1273	3715	0.8206	3.2631	3.98	390
135.0	1.053	493	2163	0.7250	1.8816	2.60	262
140.0	1.058	144	1483	0.4908	0.6878	1.40	209
145.0	1.063	0	1190	0.0000	0.0000	0.71	193
150.0	1.070	41	1052	0.2382	0.2231	0.94	184
155.0	1.079	41	880	0.2526	0.2412	0.95	170
160.0	1.090	164	718	0.6202	1.1651	1.88	141
165.0	1.105	41	454	0.3435	0.3733	1.09	110
170.0	1.126	21	334	0.2351	0.2193	0.93	96
175.0	1.157	0	245	0.0000	0.0000	0.71	87
180.0	1.209	21	183	0.2794	0.2767	0.99	76
185.0	1.312	21	108	0.3433	0.3730	1.09	56
190.0	-	41	47	0.8807	5.2669	5.98	8

Figure 1. Estimated annual landings (mt) of dolphinfish in Barbados, Grenada, and St. Vincent and the Grenadines for the

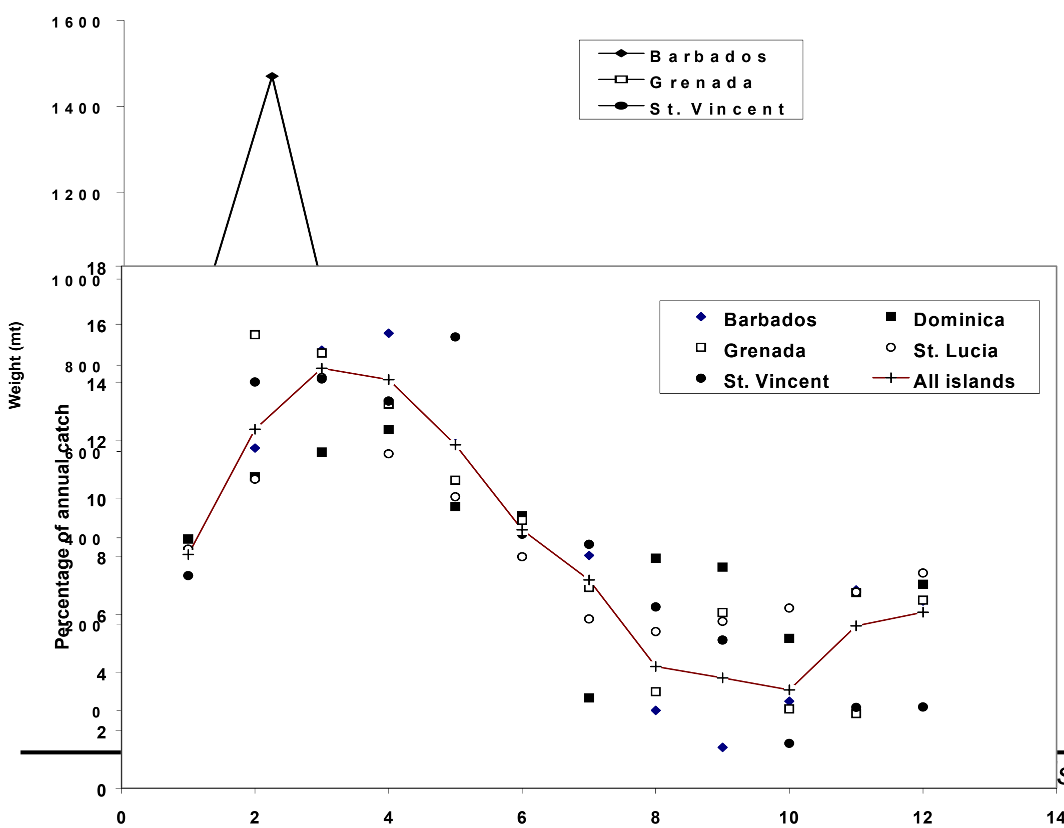


Figure 2. Percentage of total annual recorded landings in each month

Figure 3. Estimated mean fork length (cm) of dolphinfish landed in each island.

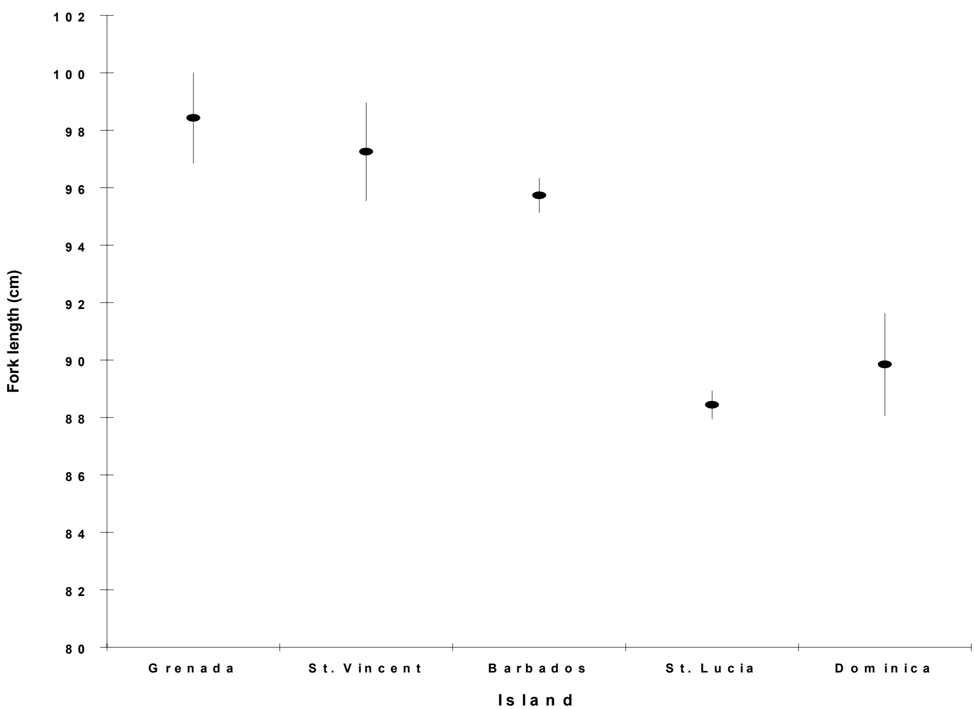


Figure 4. Estimated mean fork length (cm) of dolphinfish

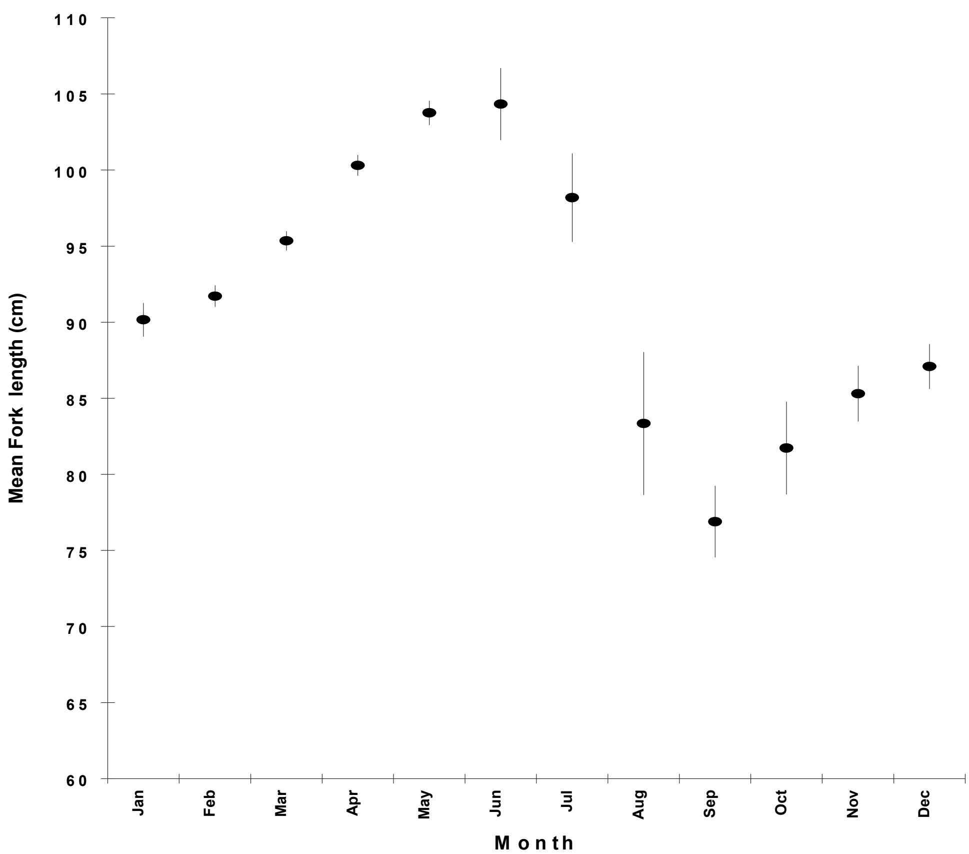


Figure 5. Estimated changes in annual mean fork length (cm) of dolphinfish landed.

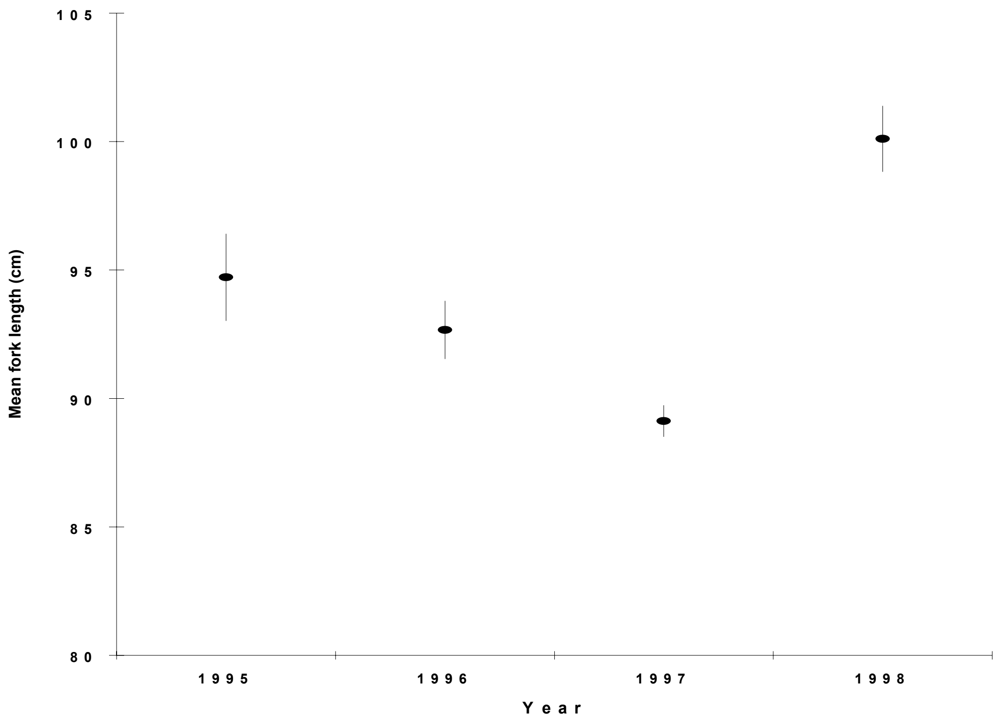


Figure 6. Gulland and Holt plot obtained from length frequency analyses of Eastern Caribbean dolphinfish data.

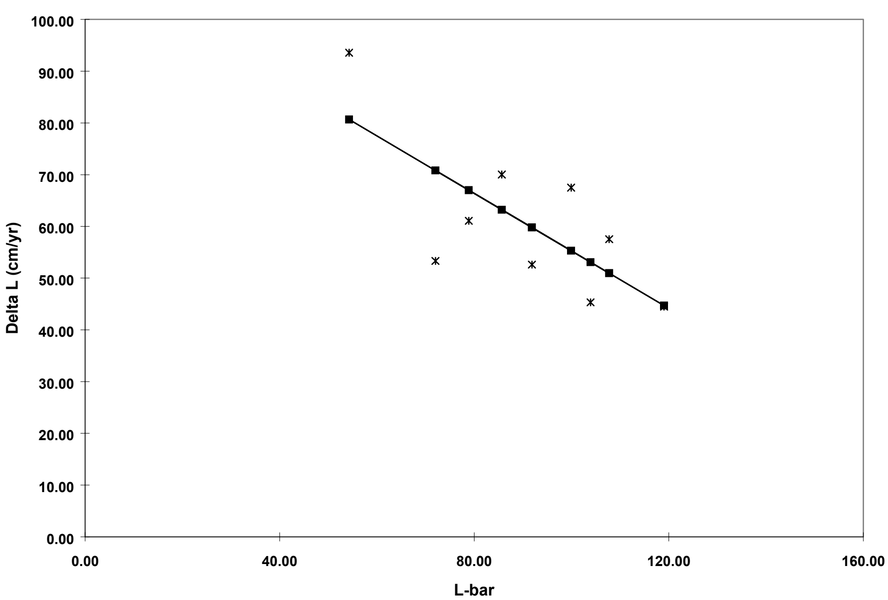


Figure 7: (a) Catch curve, with solid points indicating points selected for regression fit; and (b) linear regression fit of selected catch curve points.

(a) **(b)**

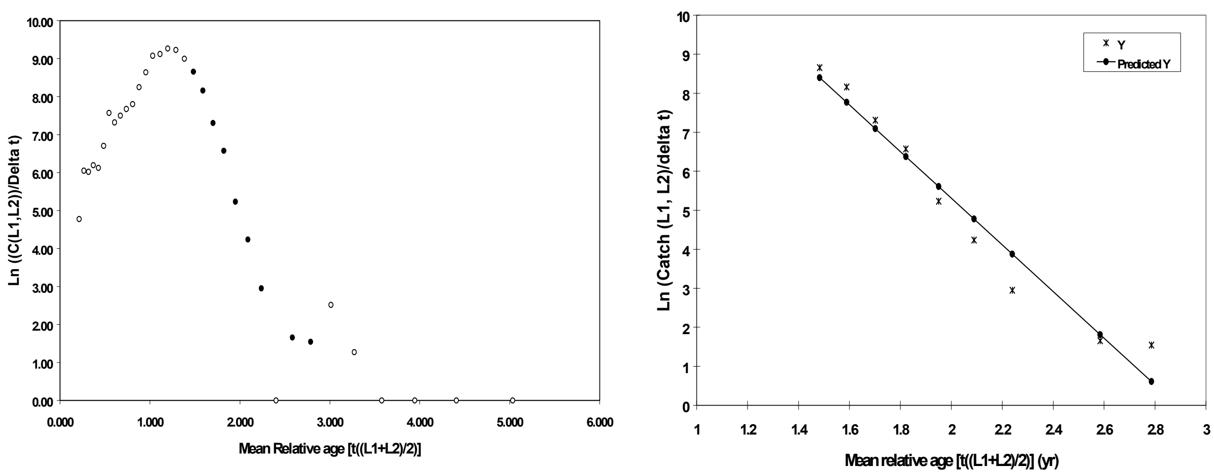


Figure 8. Yield, biomass, and value prediction curve for dolphinfish

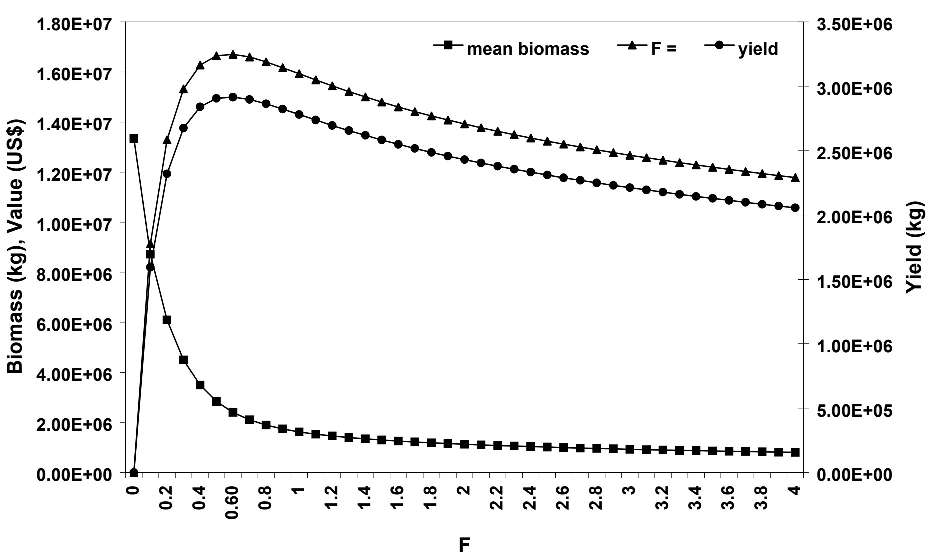
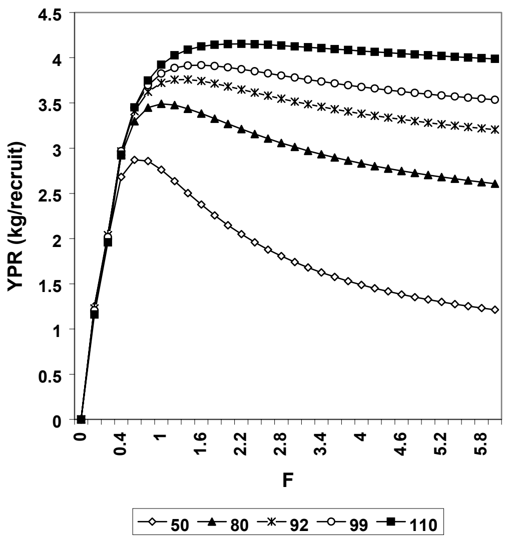


Figure 9. (a) Yield Per Recruit (YPR) analysis for dolphinfish for different values of Lc , and (b) Sensitivity to changes in M of YPR analysis assuming Lc = 99 cm.

(a)



(b)

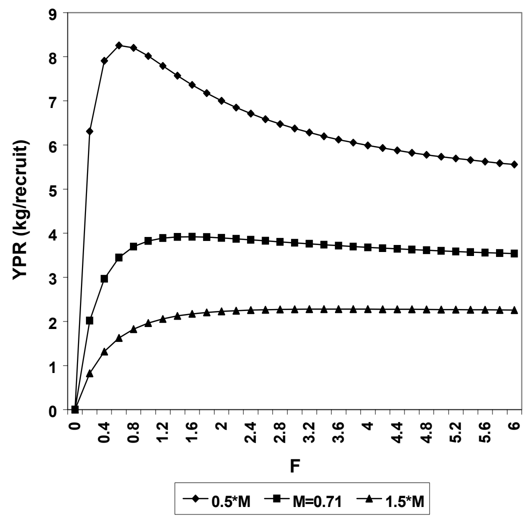
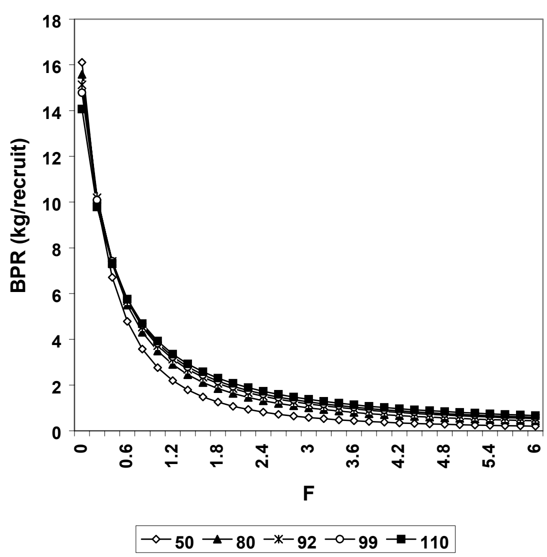
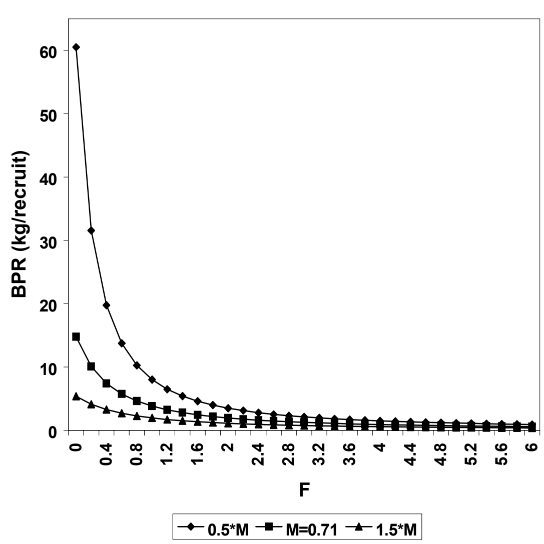


Figure 10. (a) Biomass Per Recruit (BPR) analysis for dolphinfish for different values of Lc , and (b) Sensitivity to changes in M of BPR analysis assuming Lc = 99 cm.

(a)



(b)



Working Document: CFRAMP_PRFA/2000-06

Assessment of red hind (*Epinephelus guttatus*) fishery using Eastern Caribbean Data

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Introduction

The red hind *(Epinephelus guttatus)* fishery of St. Vincent and the Grenadines is a multiple gear fishery as fishermen use traps, spear guns and various forms of bottom hand-lining to harvest this species. However, bottom hand-line is the predominant gear used. It is a small scale artisanal fishery and mechanised hauling equipment are in the experimental stages. Recently, the use of 'palang', a modified version of the simple handline with many hooks attached to increase fishing efficiency, is used with increasing frequency, and higher catch rates are obtained than for other gears. Other targeted species of this fishery include coney (*E. fulva*), parrot fishes *(Scaridae)* and grunts *(Pomadosyidae)*. The main fishing grounds for these species are the south eastern shelf of mainland St. Vincent and the eastern shelf of the Grenadines in up to 50 meters of water (Fig. 1). Red hind landings have increased since the 1980s (Fig. 2), although red hind still only comprises less than 5% of the overall landings.

The rate of the development of fishing techniques or red hind has been slow. The two methods noted above have traditionally been very popular with the fishermen of the Grenadines, with modest innovations over the years. The fishing is usually carried out all year round, however, reef fish fishing effort increases at the end of the dolphin and wahoo season (Ryan, 1999).

Double-enders of about 20 ft in length powered by 6-9 Hp outboard engines and equipped with a sail, carrying a crew of 4-5 were used before the 1980s (Mathes, 1983). Today the boats are usually the same size or bigger, but pirogues are also used with outboard engines of up to 45 Hp with a crew of three. A typical fishing day is from 4 a.m to 4 p.m. The handline is 80-120 lb tested, usually consists of 4-5 baited hooks (No. 7-9 circular galvanized hooks). Small coastal pelagics (robin, jacks, balahoo, etc) are used as bait. The fishermen deploy the lines by hand and wait for the fish to strike. Sometimes floating devices are used and the set-up is allowed to soak for several minutes. The 'palang', on the other hand, is a bottom longline of up to 300 ft in length and consists of up to 100 baited hooks. This set-up is left to soak for one or two hours before retrieving.

Traps are constructed of chicken wire using wooden frames and are about 2.3 cubic meters in volume. The 'arrow-head' trap is most common, usually baited with either fruit or fish. The traps are set at varying depths on the reefs and are checked every 5-7 days. Being a passive form of fishing the crew size seldom exceeds one.

The fishermen do not usually carry ice. Instead the catch is placed in a shaded area of the vessel or a container of some kind. The catch is usually sold fresh to the trading vessels for export to Martinique or at the local markets where it will be chilled on ice for retailing. There is no significant post-harvesting of these species but a small amount is usually dried and salted for local and domestic consumption. The normal retail price for both species is \$5.00 EC per pound. This is usually a steady price all year round but sometimes could reach \$6.00 EC per pound. Average exports for both species represent about 50% of landings.

Preparation of data for analysis

Fish catch and effort data and fish size data were collected during the period 1994-1998. Sampling coverage varied between years, with the highest number of fishing trips sampled in 1997. Length data were collected in the Northern Grenadine islands (Bequia, Petit Nevis, and the trading vessels), and at Kingstown, Greathead, and Calliaqua. Catch and effort data were collected at all landing sites throughout the country. Data were computerised using the Trip Interview Program (TIP). Data were exported from TIP into Excel and SPSS for exploratory analyses of data and preparation of input data for FISAT and cohort analysis.

A length-weight relationship for red hind was developed from a sample of fish taken during February 2000 at Bequia. Over eighty fish were sampled with length ranging from 25 to 55 cm. The estimated relationship was:

Weight = 0.005* $(\text{Length})^{2.276}$.

Statistical analyses

<u>Length data</u>

Using fish length and ln (fish length) as the dependent variables, two sets of univariate analyses of variance were performed. The first ANOVA was used to determine the effects of selected factors such as landing site, gear type, fishery type, month and year. Both the transformed and untransformed data yielded similar results, and so the results for the untransformed data were used.

In the first ANOVA, the main effects of gear type and fishery type, as well as all interactions effects were found to be significant. The final model, with landing site removed, is shown in Table 1. The differences in fish length caught by the various fishery and gear types are shown in Figs. 3 and 4 respectively. The smallest fish were taken by the offshore pelagic fishery, with the slope fishery taking the largest fish. Among the gear types deployed, the smallest fish sizes were associated with handline and trolling gear.

The second ANOVA examined monthly and yearly changes in fish length caught, as well as changes with landing site (site location) (Table 2). A full factorial model was applied, and all effects except the interaction effect, landing site* year, were significant. Monthly and yearly changes in mean fish length are shown in Figs. 5 and 6 respectively. Smaller fish are taken during the months of May-June, which may reflect changes in areas fished, a seasonal shift in predominant gears, or a recruitment phase. During the short period 1996-1998, slightly larger fish were caught during 1997-98.

Catch and effort data

Using fish weight and ln (catch weight) as the dependent variables, two sets of univariate analyses of variance were performed to determine the effects of selected factors such as landing site, gear type, fishery type, month, and year. The effort variable 'daysout' was include in the models as a covariate. Both the transformed and untransformed data yielded similar results. Ln (catch weight) followed a more normal distribution, and hence this was the variable used in the final models.

In the first model, all three factors tested (site location, gear type and fishery type), as well as the interaction effects of site*gear and site*fishery were found to be significant (Table 3). The differences in mean catch weight taken by the various gear types and fisheries are shown in Figs 7 and 8 respectively. As may be expected, the highest catch per trip was taken by the 'palang' gear, and by the slope fishery for which the red hind would be one of the main target species.

The second ANOVA tested the effects on ln (catch weight) of the following factors: site, year and month. Only the main effects of site and year were significant (Table 4). Monthly and yearly changes in mean catch weight are shown in Figs. 9 and 10 respectively. The mean catch weight of red hind showed a clear decrease during the period studies: 1994-1998. Given that the effort variable 'daysout' was included in the model, the catch weight trend reflected a catch per trip or catch rate trend, standardised for length of fishing trip. The observed overall decrease in catch per trip may therefore reflect a decline in red hind abundance.

Assessment analyses

Estimation of Growth Parameters – Length frequency data were not adjusted for selectivity prior to conducting Modal Progression Analysis (MPA). Length frequency data for 18 months for the period 1996-1998 were input into FISAT for MPA. Samples were examined using both Bhattacharya and NORMSEP routines. The growth modes so identified were used for input into the Linking of Means procedure for identification of cohorts and linkage of their growth modes. $L\infty$ and K were estimated to be 72 cm and 0.51 y^{-1}.

Estimation of mortalities – An average annual estimate of total mortality Z was obtained by means of the linearised length converted catch curve method, using an average of data over the two years 1997 and 1998. The catch curve showed considerable scatter (Figure 11a). Most points occurred in the ascending limb of the curve, and only 7 points, for lengths ranging from 48 to 62 cm, were included in the regression fit to estimate Z (Figure 11b). This may indicate that data quality and sampling needs to be improved in future. Z was estimated to be 2.78 y^{-1}, regression r^2 =0.84, 95% C. I. = [1.61, 3.95]. A cumulated catch curve was also attempted (Figure 12a). For this curve, 10 points were included in the regression fit (Figure 12b), yielding a Z of 2.42 y^{-1}, with 95% C.I. =[2.18, 2.65]. Using Pauly's formula, and assuming an average sea surface temperature of 27.5 ^{0}C, M was estimated to be 0.89 y^{-1}. In consequence, average fishing mortality was 1.89 y^{-1}.

Estimation of selectivity - Length at first capture (L_c) was estimated assuming a sigmoid-type selection ogive (Figure 13). This was considered a reasonable assumption, given the multi-gear nature of the fishery, the combined effect of which may be expected to have unit selectivity for fish greater than a certain size. Adopting Z = 2.78 y^{-1} and the corresponding intercept value of 13.08 acquired from catch curve analysis, estimated L_c = 42.9 cm, with a 95% C.I. of [85.6 cm, 95.4 cm].

Cohort Analysis and Yield and Biomass Prediction – St. Vincent's red hind catches were found to comprise on average 54% of the total Grenadines catch during the years 1996-1998. The average annual sampling coverage rate was 5.4%. The sample data were raised to reflect corresponding totals for the Grenadines area, and were used to conduct Jones' length based cohort analysis. The cohort generated F–at-size matrix and the population size of the first length group were then input into a Thompson and Bell Yield and Biomass prediction analysis. The length weight relationship used to calculate average weight at size was obtained from a study of over 80 fish, as described earlier in this report. The equation describing the relationship follows:

$$\text{Weight (kg)} = 4.94\text{E-}04 * (\text{fork length in cm})^{2.276}$$

MSY was estimated to be 252,810 lbs (114,914 kg), with F_{MSY} estimated to be 1.89 y^{-1} and $F_{0.1}$ = 0.64 y^{-1} (Figure 14). Assuming a constant price of EC$15.60/kg for all sizes of wahoo, the estimated maximum value occurred at US$ 1,448,288.00, with a corresponding F =1.89 y^{-1}. Figure 13 shows that the maxima of the yield and value curves were not very well defined, so it may be advisable to consider a recruitment overfishing reference point at 30% or 40% of initial biomass. In this case, F= 1.96 y^{-1}, and 1.07 y^{-1} for 30% and 40% of initial biomass. If 40% of initial biomass is selected as the desirable level for sustainability, then red hind may be considered to be close to full exploitation.

Yield Per Recruit (YPR) / Biomass Per Recruit (BPR) – The length based YPR/BPR model of Beverton and Holt was attempted, assuming knife-edge selectivity at L_c=43 cm. Three other values of L_c, 20 cm, 33 cm, and 53 cm, were also investigated. Length at recruitment to the fishery (L_r) was arbitrarily set at 6 cm. For all values of L_c except 20 cm, the maxima of the YPR curves were not well-defined (Figure 15a). The estimated value of $F_{0.1}$ was 1.11 y^{-1}, which is lower than the estimated current F. Sensitivity of YPR to variation in M was examined for Lc =43 cm (Figure 15b). The maximum in the YPR curve was better defined at a smaller M, with F_{msypr} =1.3 y^{-1}. The F values, that are expected to maintain the stock at 30% and 40% of its initial BPR level, were calculated to be 1.26 y^{-1} and 0.84 y^{-1} respectively (Figure 16a). Sensitivity of BPR to different values of M were also examined for L_c =43 cm (Figure 16b), and as may be expected, the sensitivity was greater at lower levels of F. Give a value of half of the current M, 40% of the initial biomass occurs at around F = 0.4 y^{-1}. Considering the values for $F_{0.1}$ and F at 40 % of initial biomass for L_c=43 cm, the YPR/BPR analysis suggests that current F levels should be reduced.

Recommendations

Given the low sampling coverage rate, these results must be interpreted with caution at this time. Specific recommendations follow.

Management:

Noting that both the analytical assessments and statistical analyses of catch rates indicate that the red hind stock of St. Vincent & the Grenadines may be fully to over-exploited, it is recommended that

1) Fishing effort for red hind should not be increased beyond current levels in the near future.

Recognising, however, the need to separate the data for mainland and Grenadines catches, and the limitations of the length-weight equation applied here, it is recommended that

2) The assessment should be updated as soon as additional improved data become available.

Data and research:

Noting the significant progress made under the CFRAMP programme in the collection and analyses of fisheries and biological data, it is recommended that

1) The field data collection program needs to be improved. Biological data collection should continue, with attempts made to improve the present sampling coverage rates. There is a need to collect information which would facilitate more detailed analyses of fishing effort and changes in fishing effort. Ideally, sampling coverage should be at least 30%.
2) It would be very useful to acquire detailed data on effective effort by gear and by trip. These data can be used to determine trends in catch per unit of effort (CPUE), which can be a reliable measure of species abundance.
3) The length frequency data should be corrected for gear selectivity prior to analyses revisions.
4) The CFRAMP / IMA regional Laboratory is conducting age and growth studies of red hind using otoliths. To date, only a limited range of lengths has been studied. Future sampling efforts should therefore ensure as far as possible that the full range of lengths are covered adequately. This work should be completed in the near future, so as to provide a necessary comparison of at least the parameter K.

Table 1: The results of an ANOVA, testing the effects of gear type and fishery type on fish length.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	142033.089(a)	21	6763.48	86.043	0
Intercept	171619.521	1	171619.52	2183.29	0
GEARCODE	31411.037	6	5235.173	66.6	0
FISHERY	2230.381	4	557.595	7.094	0
GEARCODE * FISHERY	10319.452	11	938.132	11.935	0
Error	550399.416	7002	78.606		
Total	10733731	7024			
Corrected Total	692432.506	7023			
a R Squared = .205 (Adjusted R Squared = .203)					

Table 2. The results of an ANOVA, testing the changes in fish length caught with site location, month and year.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	169822.692(a)	66	2573.071	34.253	0
Intercept	403518.333	1	403518.333	5371.65	0
SITELOCA	20327.272	7	2903.896	38.657	0
MONTH	21561.356	11	1960.123	26.093	0
YEAR	1550.809	2	775.404	10.322	0
SITELOCA * MONTH	14753.046	21	702.526	9.352	0
SITELOCA * YEAR	283.432	2	141.716	1.887	0.152
MONTH * YEAR	17313.535	12	1442.795	19.207	0
SITELOCA * MONTH * YEAR	359.271	1	359.271	4.783	0.029
Error	522609.814	6957	75.12		

Total	10733731	7024
Corrected Total	692432.506	7023
a R Squared = .245 (Adjusted R Squared = .238)		

Table 3. The results of an ANOVA, testing the effects of site location, gear type and fishery type on mean catch weight of red hind, using number of fishing days as a covariate in the model.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	273941.731(a)	137	1999.575	7.355	0
Intercept	127.703	1	127.703	0.47	0.493
DAYSOUT	62.338	1	62.338	0.229	0.632
SITELOCA	23135.586	31	746.309	2.745	0
GEARCODE	15498.969	8	1937.371	7.127	0
FISHERY	3185.053	4	796.263	2.929	0.02
SITELOCA * GEARCODE	14582.979	35	416.657	1.533	0.025
SITELOCA * FISHERY	19821.386	24	825.891	3.038	0
GEARCODE * FISHERY	3487.151	14	249.082	0.916	0.541
SITELOCA * GEARCODE * FISHERY	6183.404	15	412.227	1.516	0.092
Error	314801.67	1158	271.849		
Total	1018704.105	1296			
Corrected Total	588743.401	1295			
a R Squared = .465 (Adjusted R Squared = .402)					

Table 4. The results of an ANOVA, testing the effects of site location, year and month on mean Ln (catch weight of red hind), using number of fishing days as a covariate in the model.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	192.782(a)	102	1.89	2.716	0
Intercept	0.262	1	0.262	0.377	0.54
DAYSOUT	1.788	1	1.788	2.57	0.111
SITELOCA	33.125	12	2.76	3.968	0
MONTH	2.526	11	0.23	0.33	0.978
YEAR	19.586	4	4.897	7.038	0

SITELOCA * MONTH	15.721	31	0.507	0.729	0.851
SITELOCA * YEAR	0.886	6	0.148	0.212	0.973
MONTH * YEAR	3.835	15	0.256	0.367	0.985
SITELOCA * MONTH * YEAR	0.201	1	0.201	0.29	0.591
Error	128.02	184	0.696		
Total	1635.9	287			
Corrected Total	320.801	286			
a R Squared = .601 (Adjusted R Squared = .380)					

Figure 2. Estimated weight of Fish Landed in St. Vincent and the Grenadines for the period 1979 - 1999.

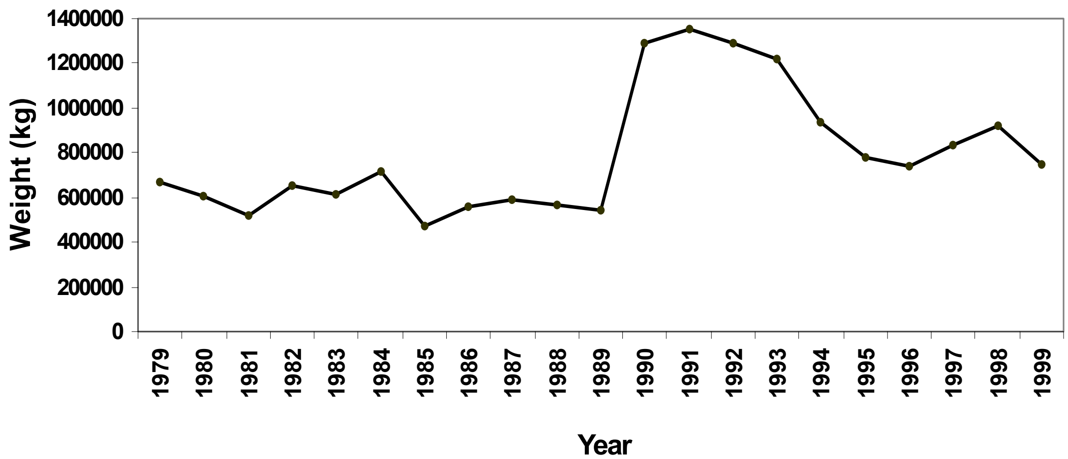


Figure 1. Chart showing main fishing areas for red hind, coney, wahoo and dolphinfish in St. Vincent & the Grenadines.

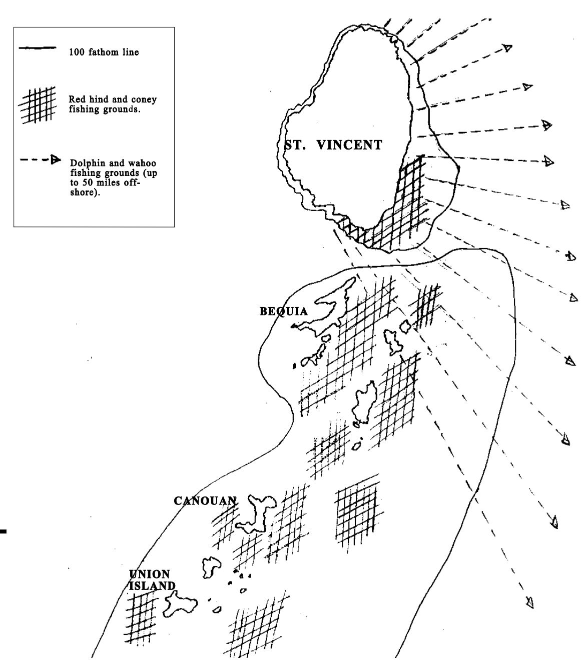
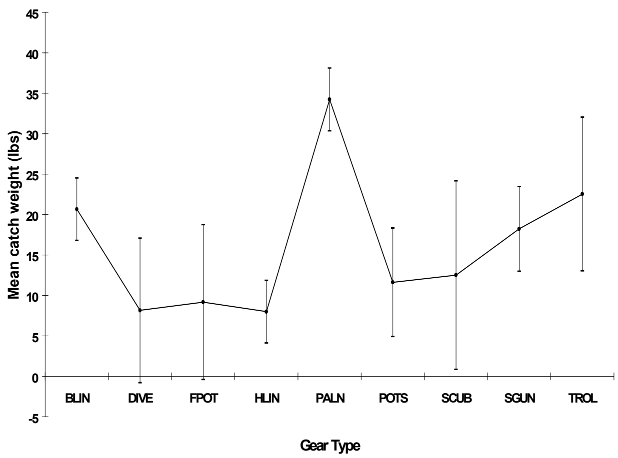


Figure 7. Mean weight of hind caught by different gears (95% confidence range shown).

Figure 8. Mean weight of hind caught by different fisheries (95% confidence range shown) [CP- coastal pelagic; MX- mixed target; OP- oceanic pelagic; RF- reef; SL- slope].



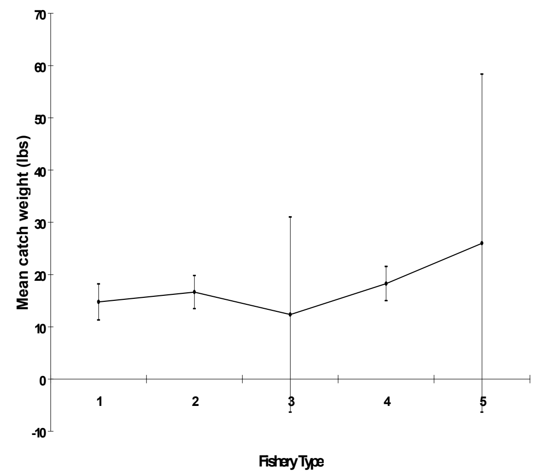
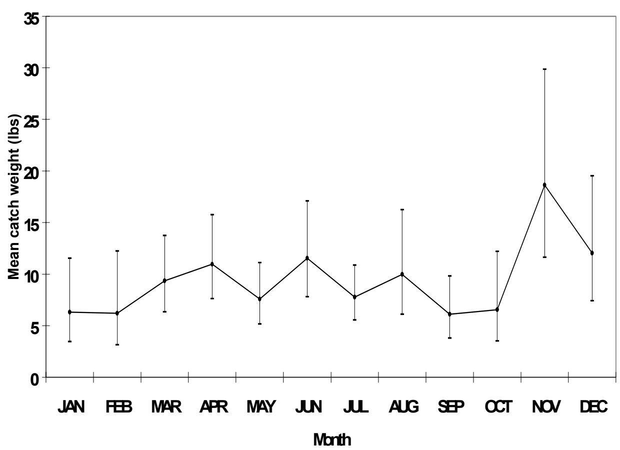


Figure 9. Monthly changes in mean weight of Figure 10. Annual changes in mean
hind, showing 95% confidence range. weight of hind for the period 1994-



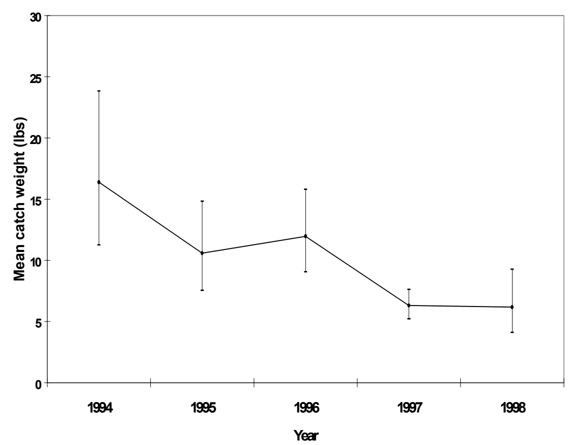


Figure 11a Catch Curve for red hind, with triangle marker showing points selected for regression fit

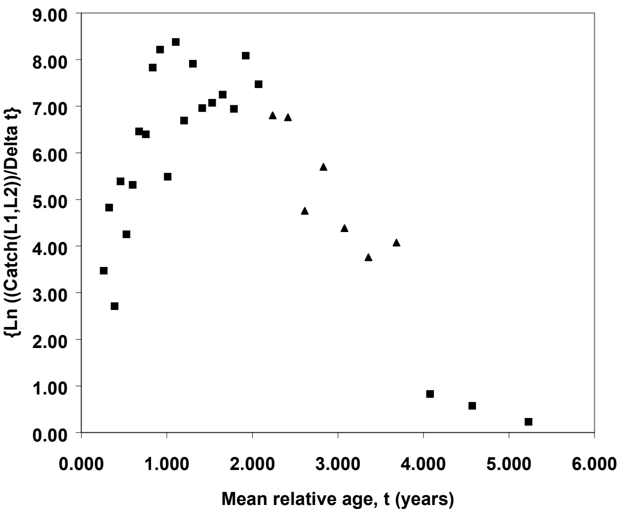


Figure 11b. Catch curve regression plot for red hind

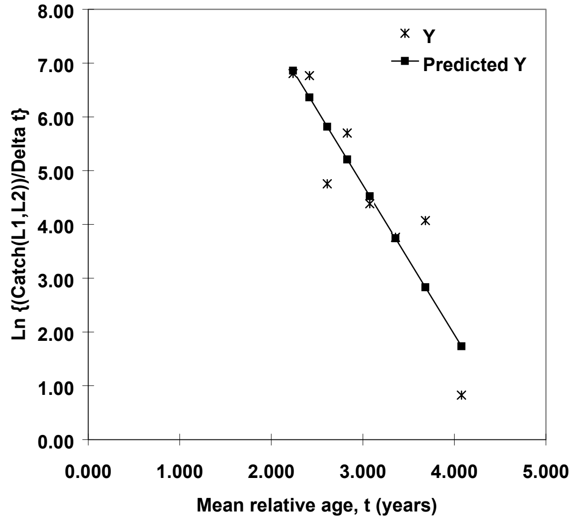


Figure 12a. Cumulated catch curve for Red Hind. Triangle marker show points selected for regression fit

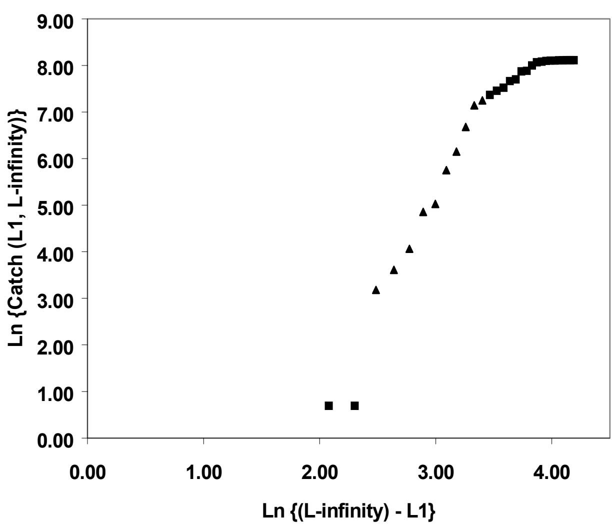


Figure 12b. Regression fit for cumulated catch curve for red hind

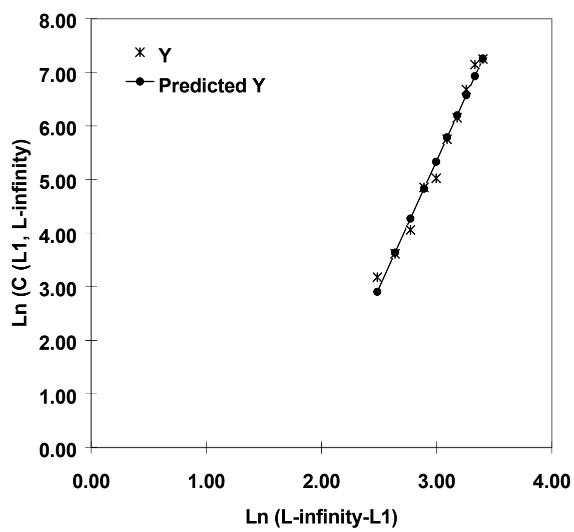


Figure 13. Selectivity Curve (S (t)) for red hind

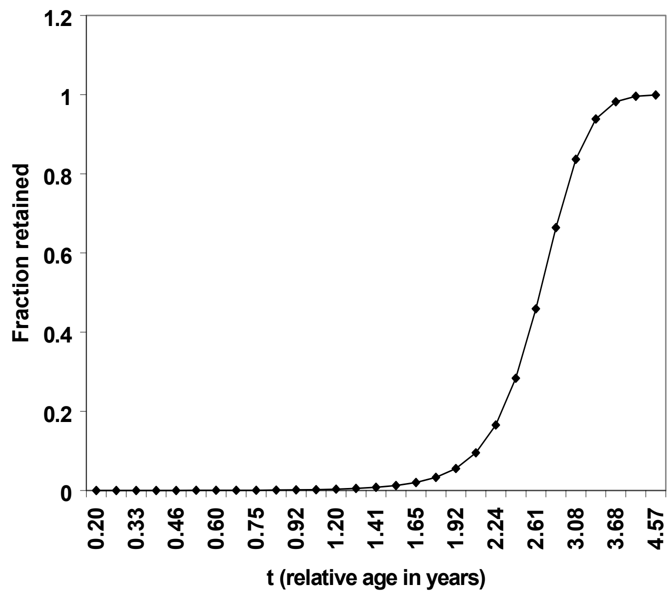


Figure 14. Yield (lbs), mean biomass (lbs) and value prediction curve for red hind

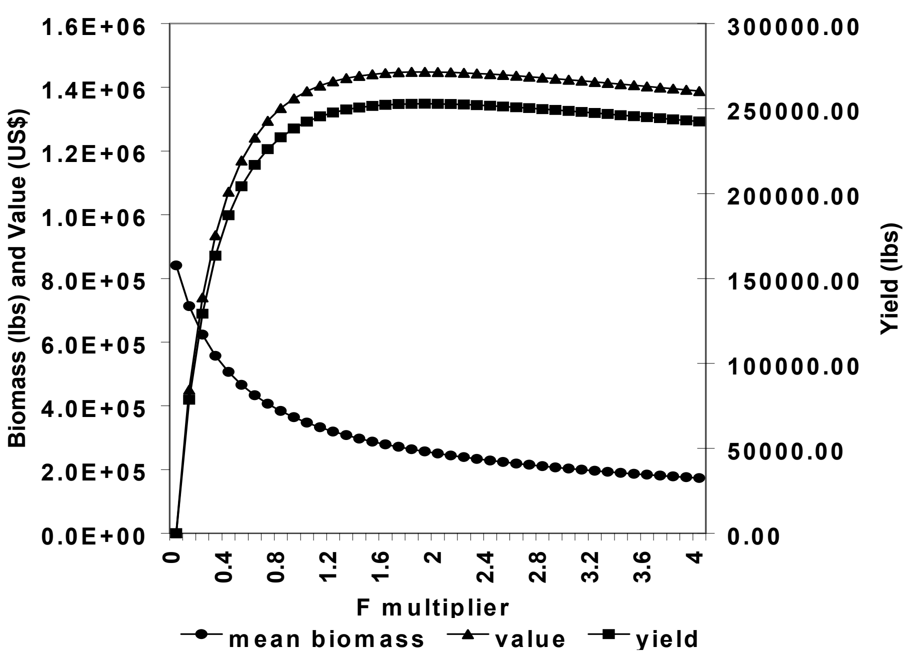


Figure 15a. YPR (lbs) for different lengths at first capture for Red Hind

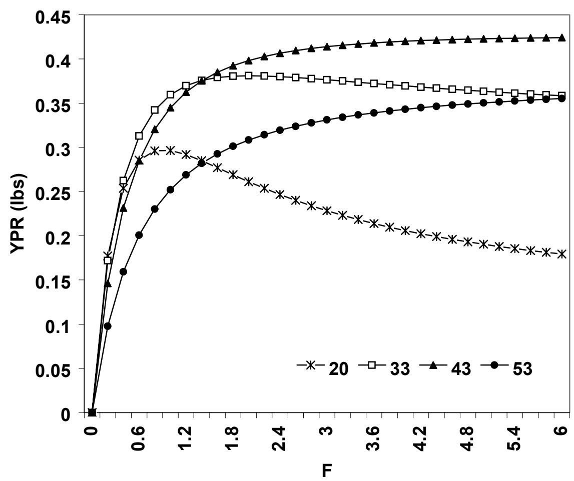


Figure 15b. Sensitivity of Red Hind YPR to estimated M

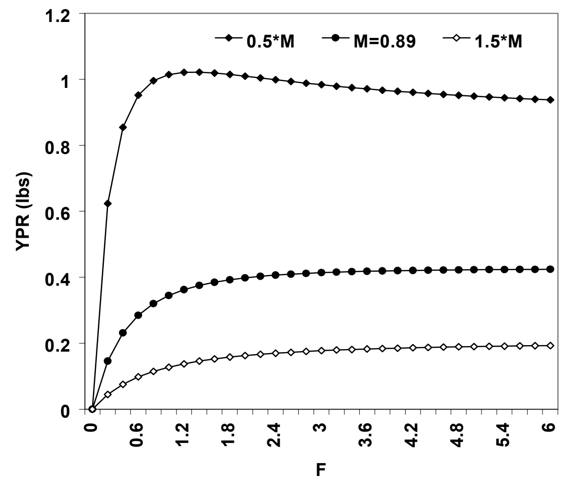


Figure 16a. BPR (lbs) for different lengths at first capture for Red Hind

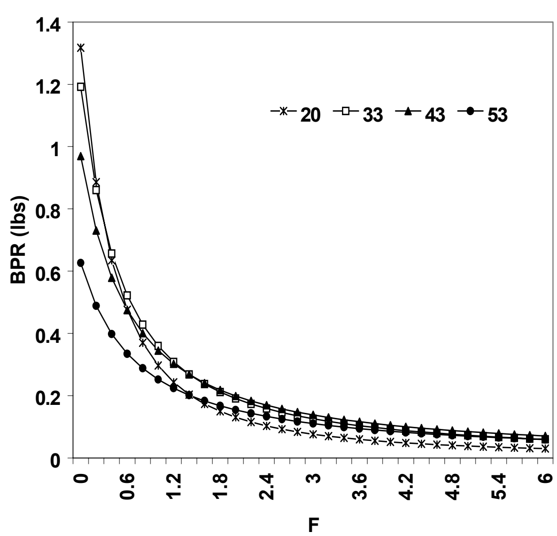
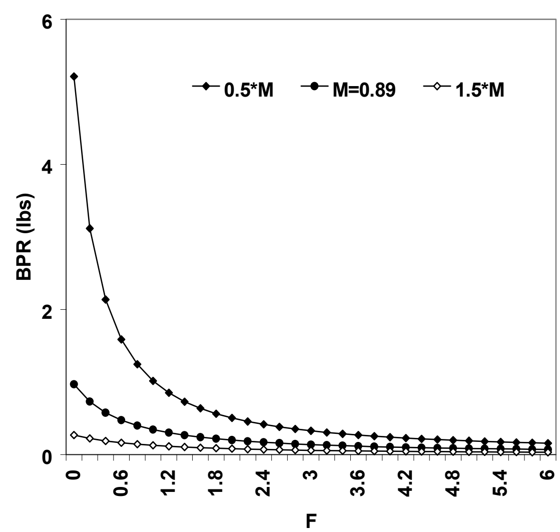


Figure 16b. Sensitivity of Red Hind BPR to estimated M



Statistical Evaluation Report of Available Fisheries Data from Five Eastern Caribbean Territories

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Introduction

This presentation indicates the steps taken in the analysis of the fisheries data that has been collected over a 6-year period. The data originally entered in TIP was exported into SPSS. Quality checks were carried out and the data variables examined to see whether analyses assuming normality would be valid. The data were transformed if necessary.

After the quality checks and transformations, ANOVAs were run using the SPSS GLIM routine. These gave interesting results, which have been presented elsewhere in this workshop.

Data collection procedures will be improved if future analyses are carried out on a more timely basis and as a result future analyses may be even more valuable.

Data collection and receipt

Detailed fisheries catch data has been collected since 1994 on three major species of fish:

Dolphin
Red Hind
Wahoo

and in five Eastern Caribbean reporting countries:

Barbados
Dominica
Grenada
St. Lucia
St. Vincent

Data was collected and entered into the computer in each country using the procedures described in the "TRIP manual" (Murray, Barnwell and Clemetson, 1995). From this the data could be read by and then exported to Microsoft Windows data handling software such as Microsoft Excel and SPSS for Windows. For the purpose of these analyses SPSS 8.0 for Windows (SPSS, 1998), licensed to CFRAMP, was utilised.

Data description

As mentioned above there were three species of fish. For each species there were two types of data files

Catch and effort data
Biological data

The catch and effort data contain one record per interview and are used for analysing information on numbers and weight of fish caught. For the biological data there are several records for each interview and these are used to analyse information on the size of fish caught; one record here represents a fish sampled. Table 1 indicates the data variables in the files and which type of data file the variable appears in. In most cases the variables appear in both types of files; in the case of the biological data most of the variable records are repeated several times for each fish sampled from the same catch. Several variables, not listed in Table 1, were also in the original data, but these were removed before analyses.

Some of the variables recorded and mentioned in Table 1 were not relevant to the analyses performed e.g. Vid, Intdate (the relevant information being recorded in Month and Year), Stardate and Enddate.

The first stage of analysis was to use the SPSS frequencies and explore routines to obtain summaries of the useful data variables in the three files.

As already mentioned, for the purposes of these summaries fields such as Sequence and Vid were not too important. If errors occur in these variables, it will not affect the analysis. The use of these variables is for identification of records and not for analysis.

The SPSS frequencies routine is used to summarise qualitative variables (e.g. Triptype and Fishery), while the explore routine is used to summarise quantitative such as Crewsize and Daysout. Some variables not listed in Table 1, occur in the SPSS summary (e.g. Bycatch); these are the variables which are included in the original dataset, but removed from the data file used for the main analyses.

The original wahoo data file examined had 10,515 records. The codes for Triptype are all valid codes from the TIP manual; the types which appear rarely e.g. 30 (long haul seines); 300 (encircling nets); 675 and 676 (surface and bottom long lines) and 900 (diving) are queried as to whether the fish type (wahoo) is relevant to that trip type. In this case (Triptype) the variable was not used in the final analysis, so any possible miscodes were not important.

Table 1. List of data variables

FIELD NAME	USED IN:		EXPLANATION
	CATCH AND EFFORT	*BIOLOGICAL*	
Sequence	X	X	Trip interview number
Triptype	X	X	Code base on gear type
Vid	X	X	Vessel registration number
Fishery	X	X	Code based on target fishery
Intdate	X	X	Date of interview
Month	X	X	Month of interview (as indicated in Intdate)
Year	X	X	Year of interview (as indicated in Intdate)
Repstate	X	X	Code for reporting country
Sitelocn	X	X	Loading site codes
Stardate	X	X	Date interview started
Enddate	X	X	Date interview ended
Infsource	X		Code for source of data
Fishmode	X		Code for mode of fishing activity
Inttype	X		Code for type of person interviewed
Landtype	X	X	Code to indicate whether landings complete
Crewsize	X	X	Number of persons in crew
Daysout	X	X	Days at sea
Daysfish	X	X	Days spent fishing
Gearcode	X	X	Code for type of gear
Soaktime	X	X	Average time gear left in water
Areafish	X	X	Code for area fished
Sizecode	X	X	Code for market category
Species	X	X	Species code
Weight	X	X	Total weight of species caught
Meastyp	X	X	Unit of weight measurement
Value	X	X	Value of catch
Price	X	X	Unit price of fish caught
Samptyp	X	X	Code for type of sample
Numfish	X	X	Number of fish caught
Linenum		X	Multiple entries for an interview are indicated
Freqy		X	Frequency of length of fish measured
Stlength		X	Length of fish
Lthtype		X	Code for type of length reached

Fishery, however, was a factor on the later analyses, so this was examined more closely. The codes here for the target fishery were CP: coastal pelagics; MX: mixed; OP: oceanic pelagics; RF: reef fish and SL: slope fish. If any of these were thought to be improbable (for example SL) then the particular record or records were found (using SPSS search facilities) and examined.

This type of procedure was done for all qualitative variables; in many instances the codes were corrected, in some instances the record was filtered out. When we are dealing with data files of thousands of records the loss of a small number because of coding errors is unlikely to be important.

It will be noticed that for some variables (e.g. Sizecode, Bycatch, and Meastyp) there were a number of blank records. In the case of Meastyp this was quite a problem as this indicates whether the weight record is in kilograms, pounds and whether the weight is gutted or whole. Obviously without this information the record cannot be used in the analysis of the fish weights.

The SPSS explore command gives measures of central tendency, variation, skewness and kurtorsis as well as pictorial information on the variables – in these examples stem-and-leaf plots and box-and-whiskers plots.

In the case of wahoo, Crewsize, Daysout, Daysfish and Gearnum only have one-eighth of values non-missing. This is partly explained by the 'multiple record" type of data and also by the "raw" nature of these data files, but sometimes this information was not available. This, of course, has serious implications when considering fishing effort.

Examination of data for Crewsize shows that 992 of the 1310 observations had a crew size of 2. A few trips (four in all) had crews of 20 or more. The box-and-whiskers plot clearly identifies the case numbers for these large crews; the records were examined and found to be large boats from the vessel id.

The variable Weight here is not very useful as it contains a mixture of units (metre and imperial) and also gutted and round weights. However another variable has been summarised - Rkweight.

Rkweight is a variable that was created using SPSS routines and all weights are in rounded kilograms. Where weights were otherwise recorded multiplication factors were used to convert to rounded kilograms. The descriptives and plots indicate that the data for Rkweight was quite skewed. The mean is almost twice as large as the median and the skewness statistic does not appear to be close to zero. The plots show that the problem is caused by a small but significant number of extreme values with a maximum at around 2000 kg compared to a median of 51 kg. Many of the very large catches are associated with the big boats mentioned earlier. The skewed nature of the data indicate that normality cannot be assumed without the data being rescaled.

Major analysis

After the files were checked and cleaned the number of records available are shown in Table 2. This shows quite a reduction on the original file size for wahoo (for example) of over 10,000.

Table 2. Number of records in data files analysed.

	Biological	Catch and effort
Wahoo	8068	6542
Red Hind	2054	1310
Dolphin	14452	26883

Two types of analysis were done for each of the six files
(a) Effect of Repstate, Gearcode and Fishery
(b) Effect of Repstate, Month and Year

For the catch and effort data the variable analysed was the weight of fish caught with Daysout as a covariate. This was the most reliable measure of effort that could be used. The weight as converted to rounded kilograms had to be transformed by natural logarithms to allow normality assumptions to hold.

The biological data variable analysed was length of sampled fish; the data for length was entered with a frequency variable indicating how many fish in sample had a particular length. Therefore the analyses had to be weighted by that frequency.

For red hind only one Repstate code was encountered so this variable had no effect on the analysis; similarly for wahoo Fishery was constant. In the case of wahoo and dolphin only HLIN and TROL Gearcode were considered relevant; other codes appearing were either recoded as appropriate or filtered out of the analysis.

The GLM routine in SPSS was used. This gives ANOVAs of the main effects and interactions as well as adjusted means and standard errors. The results of the analyses have been presented elsewhere during this workshop.

Future analyses

We have obtained some useful and interesting analyses. Unfortunately this process started rather late and trying to get six years data examined and analysed in about three months has been a little too much as most people involved in data analysis have not been able to devote a large percentage of time to the work.

However the task has now started and much progress has been made. It should be apparent that data analysis is a continuous process and starts as soon as data collection starts. What we have done is caught up with the backlog; now we need to consolidate and get on top of the problem.

The difficulties with data quality etc are a direct result of poor or no feedback from analyses. If data for an interview field are entered into TIP in 1994 and there is no feedback until 2000, it is unlikely that any problems will be corrected in 1995, 1996, 1997, 1998 or 1999. In fact the problems will probably be consolidated and may multiply.

If from now on quality checks are done regularly the data should be much better. However, it should be noted that over 80% of data collected were usable, so this is a tribute to those who were collecting the data over the years.

We have seen the differences (or lack of differences) between reporting countries, gear types and fisheries. The time sequence is not yet long enough to make conclusions about long term changes in fish catches; but there do seem to be year to year effects. There are certainly seasonal differences as well; these were probably known before this analysis, but they are now quantified and scientifically analysed.

Acknowledgement

The assistance of Mr. Marcus Jones in running the SPSS data analyses is acknowledgement with thanks.

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Age and Growth Studies at the CFRAMP / IMA Regional Age and Growth Laboratory – Progress of work done and future approaches

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Introduction

The knowledge of age and growth is fundamental to fishery science. In adult fish populations, knowledge of their age and the rate of growth is used to understand life history events, to determine the size of fish to be targeted which will maximise yield while ensuring the future of the resource, to determine the effect of fishing on the stocks, and the efficacy of management polices (Jones 1992). Techniques for age determination in teleost fishes take several forms such as the collection of marked/tagged individuals, statistical analysis of length-frequency data, and analysis of periodic structures in bony tissues.

In its Subproject Initiation Mission Report, the CARICOM Fisheries Resources Assessment and Management Program (CFRAMP) had intentions of providing most of its stock assessment advice using length-based approaches, however, such data would still require supporting data from the examination of hard parts of fish. As noted by use of length-based approaches, can sometimes yield many possible solutions, which are sometimes quite divergent. In some instances, length-based approaches may be completely inappropriate, thus making the collection of age data obligatory Morgan (1987) cited in (IMA and CFRAMP 1994). In Trinidad the Spanish mackerel, *Scomberomorus brasiliensis* locally called carite, is the most important finfish of the island's artisanal fishery. Modal progression analysis of length frequency data failed to produce growth parameter estimates for this species because of the lack of representative modes resulting from the selective nature of the gears used (CFRAMP Stock Assessment Workshop 1996). A recommendation from this Workshop was the use of hard-parts to age the fish to provide growth parameter estimates.

Under the CFRAMP Subproject "Large Pelagics, Deep-Slope and Reef Fishes Resource Assessment", the capabilities for fish age and growth studies was enhanced at the Institute of Marine Affairs (IMA) through the recruitment of staff, the procurement of equipment and a training consultancy. The role of the Laboratory was to provide age and growth information using hard parts of fish species specifically selected by various participating Caribbean countries.

The purpose of this paper is to highlight the work of the CFRAMP/IMA Age and Growth Laboratory under the CFRAMP Biological Data Collection Program. It details the methodology developed by the Laboratory for ageing the various fish species and presents preliminary growth parameter estimates for selected species, some of which have not been previously aged by hard-part determination. It also highlights some of the difficulties encountered with the sampling, which can place limitations on the growth parameter estimates and suggest ways to overcome these problems as part of the future approach of the Laboratory.

Methodology

Receipt of Hard-Parts

The CFRAMP participating countries in a Letter of Agreement (LOA) between the IMA and CFRAMP originally identified sixteen species for ageing using hard-parts. Subsequent to this, countries sent samples from an additional 13 species including the Alice Shoals Project from Jamaica. With the exception of *Balistes vetula* (Queen triggerfish) from Montserrat, which used the dorsal spine for ageing, all other species were aged using the otoliths. In most instances, only one sagitta, the otolith of choice, was received. Generally the otoliths were well cleaned (free of tissues) with minimal breakage for larger otoliths.

Otoliths samples received by the Laboratory were assigned a unique sample number and an inventory of the status of the hard parts (number, type and condition) was done for each species. This data, together with biological information sent by the country, is stored in a database specific for each species.

Otolith Preparation

All otoliths received by the Laboratory were cleaned ultrasonically and in instances where tissues were still present, cleaned in a 4:1 solution of water and 5% sodium hypochlorite (household bleach). Bleach was not used for fragile otoliths of *Acanthocybium solandri* (Wahoo) and *Thunnus atlanticus* (Blackfin tuna). Otolith morphometric measurements such as the length and weight were measured. Length measurements of whole otoliths (unbroken) were recorded from rostrum to post-rostrum (i.e. along the anterior-posterior axis) and then weighed (± 0.001 g) using a Sartorius Balance. All the otoliths (inclusive of broken and chipped otoliths where the focus was not damaged) were then placed in moulds and embedded in Spurr's Epoxy resin, which hardened overnight in an oven at 60 °C. Excess resin was trimmed from the embedded otolith using a high-speed saw. Transverse sections of the embedded otoliths incorporating the focus were obtained using a Beuhler Low Speed Saw. In some cases because of the large size of the otolith and the corresponding size of the focus, two sections were obtained per otolith. The resulting sections were then ground and polished by Lapidiary wheels using a descending series of Beuhler Grit Paper (400, 600 and 800). In the case of *B. vetula* (Queen triggerfish), dorsal spines were sectioned without embedding in resin.

Annulus Interpretation

Sectioned otoliths immersed in 95% alcohol were viewed using reflected light. The banding patterns on the sectioned otoliths were analysed using the image analysis software OPTIMAS 5.1. This was possible as a computer was linked to the OLYMPUS SCT stereomicroscope via a video camera.

Many of the annular patterns observed on the sectioned otoliths were first determined with the assistance of the CFRAMP age and growth consultant Dr. Steven Campana during a two-week training session held during April-May 1996. Some of these interpretations were adjusted and refined by the Laboratory as the receipt of samples, particularly those of larger individuals, increased. To assist in the interpretation of the position of the first annulus for some species, techniques for annulus determination were also obtained from the relevant literature.

Each annulus was interpreted as comprising an opaque (white under reflected light) zone and a translucent (dark under reflected light) zone. Annuli for the reef species were counted using the opaque zones, whilst for the pelagic species translucent zones were counted. Annuli at the margins of the otoliths were taken into consideration in age determination.

In the case of *Acanthocybium solandri* (Wahoo), annulus interpretation was based on whole otolith because of the difficulty in determining any consistent pattern, which could be interpreted as annuli on the sectioned otoliths. Franks et al (1999 in press) also experienced this difficulty using sectioned otoliths despite using several staining enhancement techniques. A primary reader aged 100 % of the readable samples. Independent secondary readings by another person are typically carried out on 20 to 50 % of the total samples (depending on sample size). Annuli diameter and focus-to-annuli measurements were recorded and used in an attempt to check the readers' consistency in annulus interpretation. Other otolith morphometric measurements included the otolith radius and otolith width or diameter. All measurements were recorded using OPTIMAS 5.1. Digital images of reference samples for each species are stored in the Laboratory's Reference Collection Database.

Validation

Many marks exist on the otolith however their pattern of formation is not consistent, suggesting that they might be reflecting something other than annuli. Therefore, a consistent and/or experienced is not necessarily an accurate age reader. To confirm accuracy, validation is required, i.e., the confirmation of the temporal nature of these presumed annuli. It is important to note that the appearance of these annuli change substantially in different environments, and annuli, which are valid in one area, may not necessarily apply in another area. Several validation techniques exist such as monitoring of known-age larvae, chemically marking otolith, inferences from older fish, marginal increment analysis and microstructure analysis.

The Laboratory employed the latter two validation techniques, which were more tractable to the operations of the Laboratory. Marginal increment analysis involves determining the temporal nature of the deposition of either the opaque or translucent zones by following the frequency of the edge types (opaque or translucent) of the sagitta with time. Edge type was viewed using the Optimas 5.1 software**. It must be noted that samples need to be collected fairly regularly over a minimum of one year**. Dr. Campana (1996) had suggested that if marginal increment analysis was to be used it should cover a period of at least two years.

Microstructure analysis was performed on the Spanish mackerel, *Scomberomorus brasiliensis* (carite). Lapilli of young-of-the-year (YOY) carite up to and including the size of presumed first annulus formation (in the corresponding sectioned sagitta) were used to enumerate presumed daily increments. Enumeration of daily increments was facilitated by mounting the whole lapilli on glass slides and embedding in Krazy Glue. The embedded lapilli are then polished using 2 grades (3 and 8 μm) of metallurgical lapping film.

Data Analysis

Observed mean length-at-age data from the age determinations were used to generate growth parameter estimates using FAO-ICLARM Stock Assessment Tools (FiSAT) computer program and the corresponding growth curve re-constructed in EXCEL.
Focus to annuli and annuli diameter plots of otolith morphometric measurements were used to determine the accuracy and precision of both the primary and secondary readers' annuli interpretations and age bias plots to determine any bias between the readers.

Results

Selected species have been used to highlight the work and outputs of the Laboratory. Many of these species had presumed annuli, which ranged from very clear to relatively clear. Figures 1 to 9 highlight the presumed annuli for some species as interpreted by the Laboratory.

Queen Triggerfish

All of the 220 dorsal spines of *B. vetula* received by the Laboratory from Montserrat were collected by fish pots from the artisanal fishery. Figure 1 highlights presumed annuli on the sectioned spines of *B. vetula*. These sections were viewed using transmitted light, so that the opaque zones of the annuli are typically the dark bands and the translucent zones, the white bands.

Based on the von Bertalanffy growth model shown in Figure 10, the growth parameter estimates are L_∞ = 75.0 cm, K = 0.07 yr^{-1} and t_0 = - 4.33 yr. The growth curve shows that while there is a good spread of age groups, the absence of age I fish has resulted in a high t_0 value. Additionally small samples of young fish, 1, 3 and 15 for age I to III respectively, also contribute to the high to value. More samples of the younger age groups are needed to refine the growth parameter estimates.

Lane Snapper

Most of the sectioned sagittae of the lane snapper, *Lutjanus synagris* collected from Belize had relatively clear annular banding patterns. Figure 2 highlights the presumed annuli for this species as interpreted by the Laboratory. The resulting growth curve Figure 11 and growth parameter estimates L_∞ = 26.5 cm, K = 0.13 yr^{-1} and t_0 = -10.0 yr, are based on this annular interpretation. Despite the quality control taken with respect to accuracy and precision of annuli interpretation (Kishore 2000), the resulting growth parameter estimates illustrates relatively low L_∞ and K values and a high t_0 value. Several reasons could have caused these results such as the small sample size (n = 88), general absence of Age I and II fish, under representation of samples at extreme ends of the size range and small number of samples within the age groups. **Generally growth parameters are determined by the size of the sample, the length of the largest fish, the age of the oldest fish, the separation or lack of separation of sexes and methods of back-calculation**.

When these parameters are compared with other studies for the Caribbean (Rodriguez Pino 1962, Claro and Reshenikov 1981, Manooch and Mason 1984, Manickchand-Dass 1987, Pedroso and Pozo 1991, Pozo *et al* 1991 and Johnson *et al* 1995), the growth parameters particularly the L_∞, is lower than expected. However with the exception of Manooch and Mason (1984) and Johnson *et al* (1995), all other studies for the Caribbean are based on annular interpretations using whole otoliths. However ages determined for the lane snapper by this Laboratory are comparably to Johnson et al (1995) for lane snapper for the northern Gulf of Mexico whose 9 years olds range from approximately 30 to 50 cm and whose oldest fish was 17 years at a length of 50 cm. **Therefore before any conclusion can be drawn on this growth pattern determined by the Laboratory for the lane snapper from Belize, more samples covering the entire size range and adequate sample number within an age groups are needed to confirm this growth pattern.** If this growth pattern is confirmed, then the obvious implication is for a slow growing rather than a fast growing stock and the resultant implications for management of this stock.

<u>Doctor fish</u>

Montserrat sent sagittae of *Acanthurus chirurgus*, doctor fish, for ageing. Most of the otoliths had relatively clear bands, Figure 3, however as with most of the species it was difficult to identify annular patterns on both the ventral and dorsal lobes of the sectioned otoliths.

Of the 167 samples received by the Laboratory, 153 were in the 11 – 20 cm size range. This limited size range again affected the growth curve and generating growth parameter estimates of L_∞ = 39.0cm, K = 0.083 yr^{-1} and t_0 = - 4.307 yr, Figure 12.

Craig (1999) noted that for the surgeonfish *Acanthurus lineatus* in Samoa, equally good but very different fit to the same data when the youngest fish were excluded, resulting in different growth parameter estimates based on the von Bertalanffy growth model. This occurs because K and L_∞ are strongly age-dependent. He also noted that the sliding scale of K and L_∞ values introduces considerable subjectivity into the analyses. This uncertainty is amplified when the values are used to estimate natural mortality or total mortality from length-converted catch curves. A stock might erroneously be managed as fast-growing, short-lived species. One suggestion from Craig (1999) is the recognition of two separate growth phases in the growth curve. The data for *A. chirurgus* also suggests that this fish exhibit very fast growth in the first few years of life followed by a long period of asymptotic growth. This type growth pattern was also noted by

Choat and Axe (1996) for 10 species of acanthurids from eastern Australia, which exhibited 80% of linear growth in the initial 15% of the life span with life spans ranging from 30 to 45 years.

Squirrelfishes

Montserrat sent sagittae of both the longjaw squirrelfish *Holocentrus adscensionis* and longspine squirrelfish *H. rufus*, for ageing. There were relatively clear banding patterns on the sectioned sagitta of both species, Figures 4 and5, with the first annulus being at a considerable distance from the focus indicating rapid growth in the first year. For both of these species however, the size range was again narrow. For *H adscensionis*, of the 106 samples received, 101 were from the 16 – 25 cm size range while for *H. rufus*, of the 166 samples, 155 were from the 16 – 20 cm size range.

Despite the relatively good fit of the data to the von Bertalanffy growth model, Figure 13, the absence of young fish and the small size (length) of the oldest fish has produced the following growth parameter estimates, L_∞ = 24.9 cm, K = 0.252 yr^{-1} and t_0 = - 1.625 yr. This growth pattern is similarly seen for *H. rufus*, Figure 14, producing the growth parameter estimates L_∞ = 19.55 cm, K = 0.16 yr^{-1} and t_0 = - 10 yr. The presence of one fast growing Age I fish and small (length) but old fish has produced a high t_o value and low L_∞ value.

Groupers

The two grouper species the coney, *Cephalopholis fulva* (=*Epinephelus fulvus*) and the red hind, *Epinephelus guttatus* presented in this report are from Dominica and Grenada respectively. Both grouper species exhibit annular banding patterns, which are more broad and diffuse than the other reef species reported in this report, Figures 6 and 7.

The samples of groupers received again were narrow in their size range. Although the data also fit well the von Bertalanffy growth model, Figures 15 and 16, the small sample numbers of 30 and 56 for the coney and red hind respectively and the absence of young fish, affected the growth parameter estimates for the coney L_∞ = 46.5 cm, K = 0.15 yr^{-1}, t_0 = - 2.409 yr and for the red hind L_∞ = 47.26 cm, K = 0.133 yr^{-1}, t_0 = - 2.409 yr.

However despite small sample size, comparison of the growth parameter estimates for *E. guttatus* with those in the literature are similar. Growth parameters for the red hind from Bermuda are L_∞ = 50.7 cm, K = 0.18 yr^{-1}, t_0 = - 0.44 yr based on L_{max} value of 57.5 cm (Burnette-Herkes 1975) and from Puerto and St Thomas are L_∞ = 51.5 cm, K = 0.10 yr^{-1}, t_0 = - 2.94 yr (based on L_{max} value of 49 cm) and L_∞ = 60.1 cm, K = 0.07 yr^{-1}, t_0 = - 4.69 yr (based on L_{max} value of 50.4 cm) respectively (Sadovy 1992). The high t_o values in these studies is also due to the absence of young fish in their analyses.

Wahoo

The wahoo, *Acanthocybium solandri* was selected for ageing by St. Lucia and Barbados because of its commercial value. A similar problem with respect to the size range was experienced in that most of the samples received by the Laboratory were from the 90 – 110 cm size range. This prevented the determination of annular banding patterns on the sectioned otolith given that scombrids usually exhibit fast growth, so that samples from this size range may not necessarily be old fish which are needed for annulus interpretation. Previous annular assessment of this species by Campana (1996) indicated that this species could not be aged using otoliths and recommended the examination of sectioned fin rays, vertebrae or opercula for annular patterns. This recommendation was based on the limited samples particularly of large individuals collected at that time. Subsequently, examination of both pectoral and dorsal spines By the Laboratory of Wahoo collected at a Hard-part Removal Workshop in St. Lucia revealed unclear banding patterns. The lack of associated length data for these samples made this examination inconclusive.

Based on the assumption that the wahoo in the Caribbean is generally thought to be of one stock, the Laboratory collected larger individuals (>120 cm) from Gamefishing Tournaments from Trinidad and Tobago during the period November 1998 to November 1999. In addition, Wahoo from the artisanal commercial fishery in St. Vincent were collected by CFRAMP mainly covering the lower end of the size range (<100cm).

Annulus interpretation first attempted on the sectioned otoliths was difficult and inconsistent, Figure 8. The corresponding banding pattern on the whole otolith, Figure 9, was clearer and more consistent and this method was adopted for subsequent age determination.

Ages for the wahoo ranged from young of the year to 10 years. The resulting growth parameter estimates, L_∞ = 153.97 cm, K = 0.34 yr^{-1}, t_0 = - 1.544 yr and growth curve are seen in Figure 17. This data show a very good fit of the von Bertalanffy growth model, and show good coverage of samples across the size range. Differentiation of half-years was noted for some samples of young fish late in the age determination process and was factored into the generation of these growth parameters. Re-aging of some samples therefore has to be re-done and the growth parameters refined.

Additionally, length/weight relationship of wahoo was determined from data gathered from the Gamefish Tournaments and from the commercial catch from St. Lucia, Figure 18. Regression of the log transformed data revealed a very good fit log y = 3.862 log x – 7.050 (r^2adj = 0.9614).

Validation

The Laboratory focussed on two validation techniques, marginal increment analysis and microstructure analysis. Marginal increment analysis was determined by following the edge type of the sectioned and whole otoliths with time. No attempt was made to measure the edge because of the variability of the edge thickness along the lobes of the section. Marginal increment analysis could only be done for samples from Trinidad (kingfish, carite, and cavali and wahoo) because samples from the other CFRAMP countries were not collected on a regular basis over a minimum of a one-year period to facilitate this type of analysis. An example of marginal increment analysis is seen for the cavali *Caranx hippos* in Figure 19. It shows that one translucent zone is deposited over a one-year period. This infers that the annual increment (= an annulus) comprises an opaque and translucent zones and age can be determined by enumerating either the opaque or translucent zones.

Microstructure analysis of the lapillus (daily increments) was used to validate the position of the first annulus on the sectioned sagitta of *S. brasiliensis* (carite) from Trinidad.

The embedded lapillus of carite after polishing showed very clear presumed daily increments typical for species in temperate countries, Figure 20. These increments on the lapillus were extremely clear and regular, and while the increments were not validated as daily, they can be safely assumed to be such (Campana 1996). Each presumed daily increment consists of a light and dark zone or band. A second order polynomial curve through the origin of the daily increments plotted against fish length fitted extremely well, suggesting a length of 47.0 cm (Kishore and Martin 1998). This data compares favourably with mean-length-at age I of 47.1 cm and 49.1 cm for males and females respectively based on annular interpretations of sectioned sagittae. Validating the position of the first annulus on the sectioned sagitta was very important given the discrepancies of the mean length-at-age I present in the literature. Mean length-at-age I for carite ranged from 18 – 39 cm (Nomura 1967, Sturm 1968, Ximenes 1981 and Julien-Flüs 1988). For this species, fish that were previously aged as Age I, II and III would now be aged as young of the year and Age I fish. The resulting implication for fisheries management of the stock is that exploited fish previously thought as adults would now be considered juveniles resulting in about 85% of the commercially caught carite for 1996-7 being classified in the 0-2 yrs age group with approximately 50% being young-of-the-year (YOY) fish. This data also provides scientific information for management strategies such as increases in mesh sizes of the gear used, in this case, gillnets.

Future approaches

The work presented in this report highlights the development and progress of the CFRAMP/IMA Age and Growth Laboratory.

- The Laboratory has been able to develop a methodology for routine processing and ageing of commercially important fish in the Caribbean.
- It has shown that presumed annuli are present on both whole and sectioned otoliths with characteristics common to fish species around the world. For some of these species this represented the first-time ageing using hard-parts.
- Produce growth parameter estimates for most of the species thus far aged.

Despite reasonable to very clear presumed annular patterns, many of the growth parameter estimates derived were limited by the absence of both young and old fishes in the respective samples as well as by the size of the samples from the various countries. It must be reiterated that these growth parameters and growth curves are dependent on the sample size, the size of the largest fish, the age of the oldest fish, the separation or lack of separation of the sexes, therefore it is a key recommendation of this report that samples be collected for species for which the size ranges were limited in order to refine some of these growth parameter estimates. For species with limited size ranges, additional samples can be added to those already collected. The sample size of 300 fish per year as recommended under the CFRAMP Biological Data Collection Programme still is appropriate. The generation of reasonable growth parameter estimates based on hard-part determination is especially important because it provides an alternative to the length-based approach in view of the unimodal nature of the length frequencies of the commercial catch resulting in no reasonable growth parameter estimates being produced.

For most of the CFRAMP species aged by the Laboratory the absence of young fish has produce growth curves, which fit the data very well but has produced growth parameter estimates, which in some instances are different from the available and relevant literature.

Despite the limitation to some of the growth parameter estimates generated, the annuli interpretations and the resultant growth rates suggest that the commercial fish species in the Caribbean are slower growing than previously thought and seem to exhibit two phases of growth; a fast period during the first few years followed by a second phase of asymptotic growth as noted for tropical fishes by Choat and Axe (1996) and Craigg (1999). The development of two different von Bertalanffy growth models to capture these two phases of growth implicitly would lead to the development of two values for natural mortality and total mortality, which is more realistic when compared to the assumption that mortality is constant across the age groups. The Laboratory would like to experiment with different growth models and work with other age and growth laboratories particularly for verification of age readings and for training.

The Laboratory would like the inclusion of microstructure analysis for validating the position of the first annulus on the sectioned sagitta and ageing of short-lived fish species in routine ageing work of the Laboratory. Microstructure analysis has proven to be very useful, however the daily increments seen on the hard-part are presumed to be as such until they themselves are validated. This requires that the hard-part selected for microstructure analysis be collected at the same time as that of the hard-part selected for annular interpretation. To provide confirmation of these presumed daily increments requires the chemical marking of lapilli of juveniles kept in confined conditions (possible outdoor cages or indoor tanks) for a known period of time. The Laboratory has been successful in keeping juveniles of cavali and weaning them onto dead bait for a period of time. However a re-circulating seawater system has to be developed and properly maintained (conditions have to remain constant as not to upset daily growth patterns) and microstructure analysis techniques developed for each selected species (preparation of hard-parts for microstructure analysis varies among the species).

Apart from ageing, hard-parts particularly otoliths have been used for other studies, which include stock identification, identification of nursery areas based on elemental composition of the otolith and the use of otoliths to indicate pollution. The Laboratory has initiated some research with respect the use of otoliths in uptake of heavy metals in fish. The possibility of exploring these areas of research should be investigated given the role environmental factors have on fish stocks. However the Laboratory would like to concentrate its efforts on age and growth studies of commercially important species for the region.

This future approach of the Laboratory should be based on a decision, which involves the Laboratory and the participating countries of CFRAMP. In this light it is necessary to improve communication between the Laboratory and other CARICOM countries. It is hoped given the relatively clear annuli present on the hard-parts and improvements made to the data collection and the difficulty in generating growth parameter estimates based on length frequency analysis for some species that age-based stock assessment using ages derived from hard-parts can become a reality.

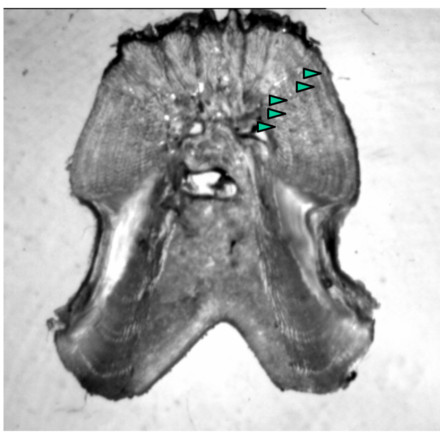


Figure 1 Sectioned dorsal spine of *Balistes vetula* from Montserrat showing 5 presumed annuli on a 30 cm (TL) fish - BV 96/04/12.

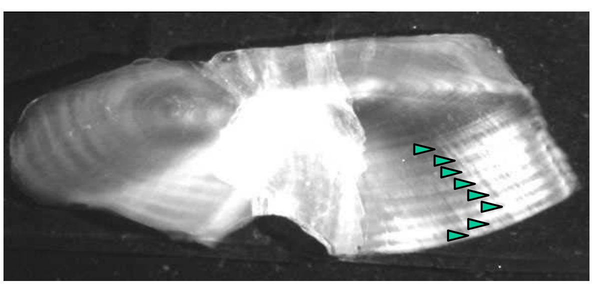


Figure 2. Sectioned sagitta of *Lutjanus synagris* from Belize showing 8 presumed annuli on a 25.5 cm (TL) fish. - LS 97/02/84

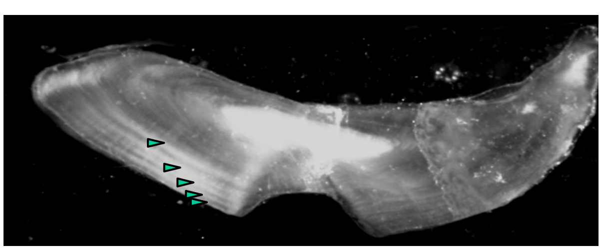


Figure 3. Sectioned sagitta of *Acanthurus chirurgus* from Montserrat showing 5 presumed annuli on a 20 cm (TL) fish - AC96/12/02

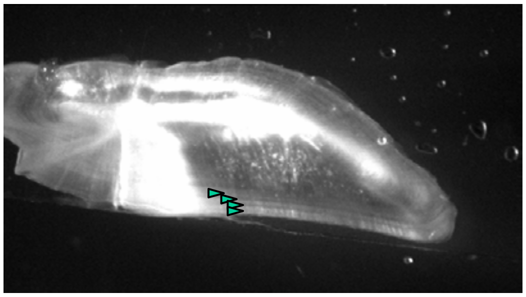


Figure 4. Sectioned sagitta of *Holocentrus adscensionis* from Dominica showing 4 presumed annuli on a 19.0 cm (TL) fish - HA 97/02/10

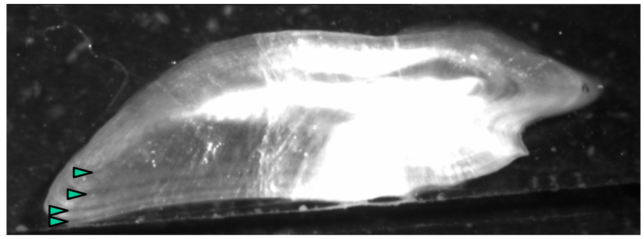


Figure 5. Sectioned sagitta of *Holocentrus rufus* from Dominica showing 4 presumed annuli on a 16.0 cm (TL) - HR 97/02/05

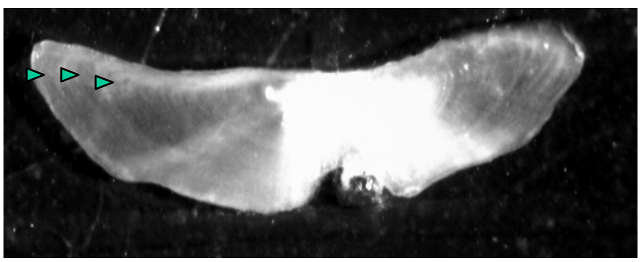


Figure 6. Sectioned sagitta of *Cephalopholis fulva* from Dominica showing 3 presumed annuli on a 23.0 cm (TL) - EF 96/02/11

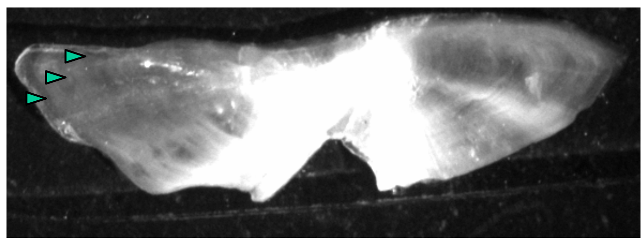


Figure 7. Sectioned sagitta of *Epinephelus guttatus* from Grenada showing 3 presumed annuli of a 30 cm (TL) fish - EG 95/08/02

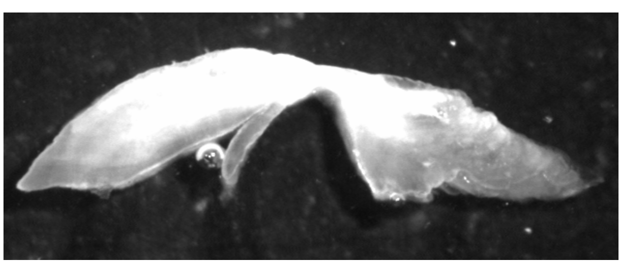


Figure 8. Sectioned otolith of *Acanthocybium solandri* from Tobago showing no clear annular banding patterns - AS 98/11/37

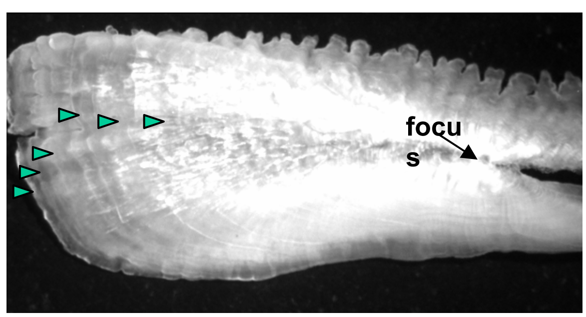


Figure 9. Whole otolith of *Acanthocybium solandri* from Tobago showing 6 presumed annuli of a 137 cm fish - AS 98/11/37

Figure 10. The von Bertalanffy Growth Model for the Queen triggerfish, *Balistes vetula* from Montserrat.

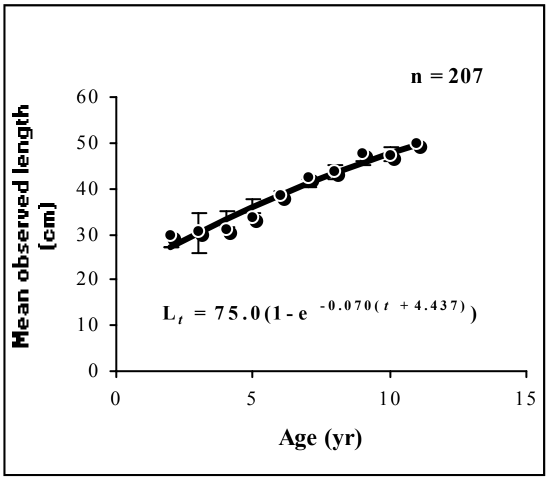
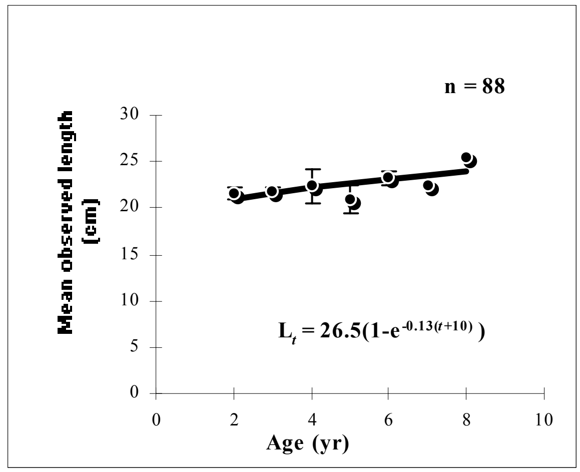


Figure 11. The von Bertalanffy Growth Model for the lane snapper, *Lutjanus synagris* from Belize.



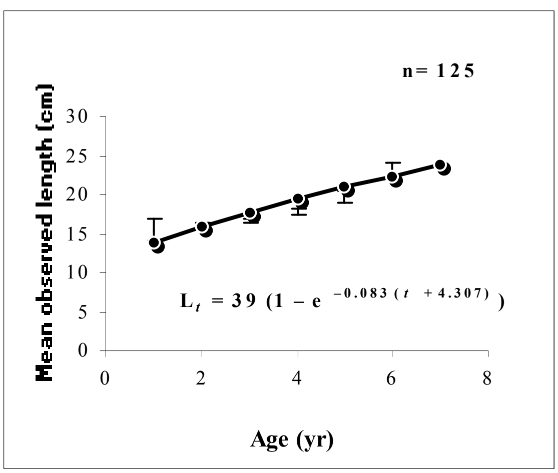


Figure 12. The von Bertalanffy Growth Model for the doctor fish, *Acanthurus chirurgus* from Montserrat.

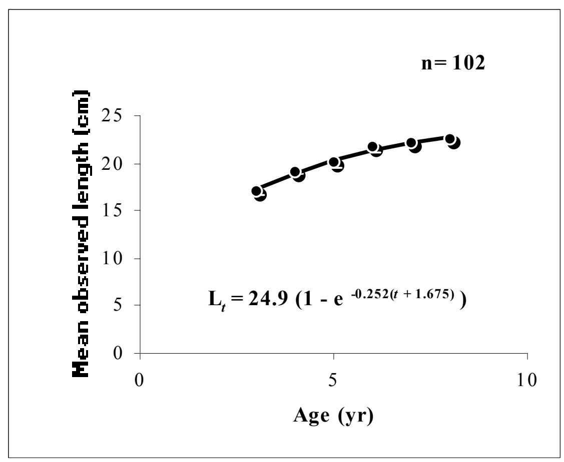


Figure 13. The von Bertalanffy Growth Model for the longjaw squirrelfish, *Holocentrus adscensionis* from Dominica.

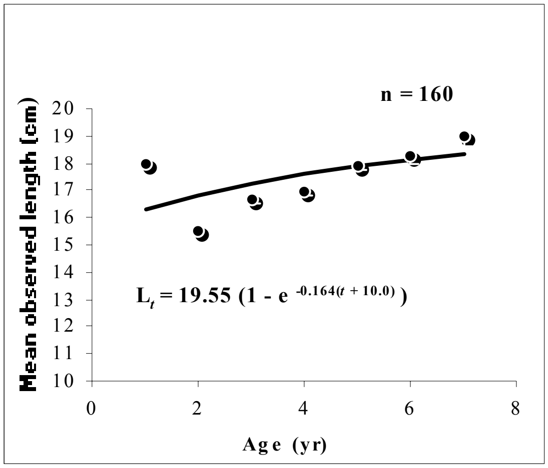


Figure 14. The von Bertalanffy Growth Model for the longspine squirrefish, *Holocentrus rufus*, from Dominica.

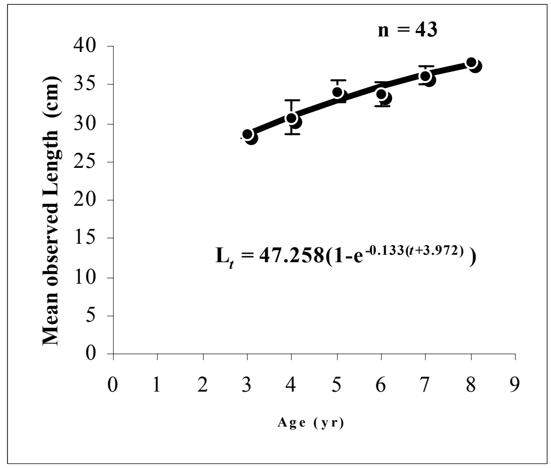


Figure 15. von Bertalanffy Growth Model for the red hind, *Epinephelus guttatus*, from Grenada.

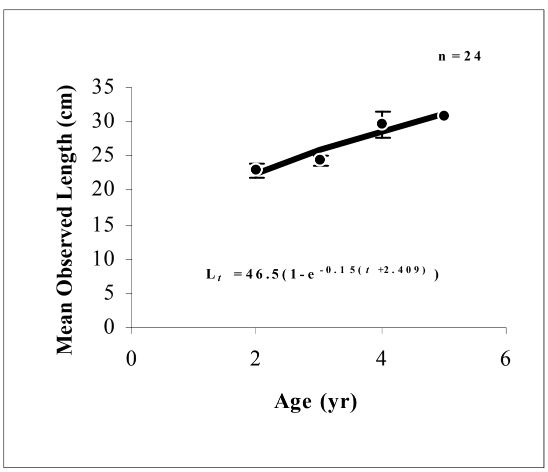


Figure 16. The von Bertalanffy Growth Model for the coney, *Cephalopholis fulva*, from Dominica.

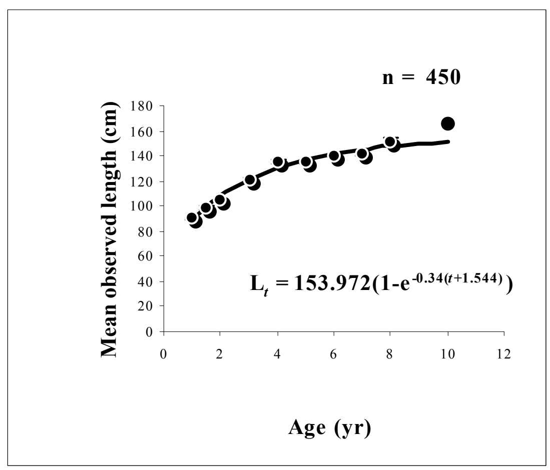


Figure 17. von Bertalanffy Growth Model for the wahoo, *Acanthocybium solandri*, (combined samples from St. Vincent, St. Lucia, Barbados, Trinidad and Tobago).

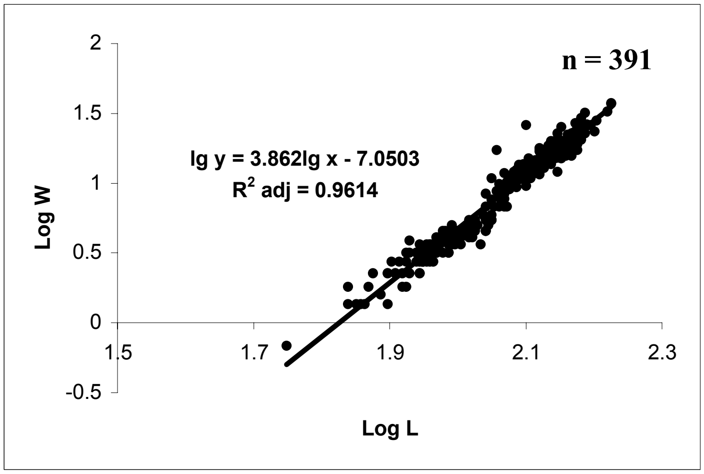


Figure 18. Length/weight relationship for *Acanthocybium solandri* from St. Lucia and Trinidad and Tobago.

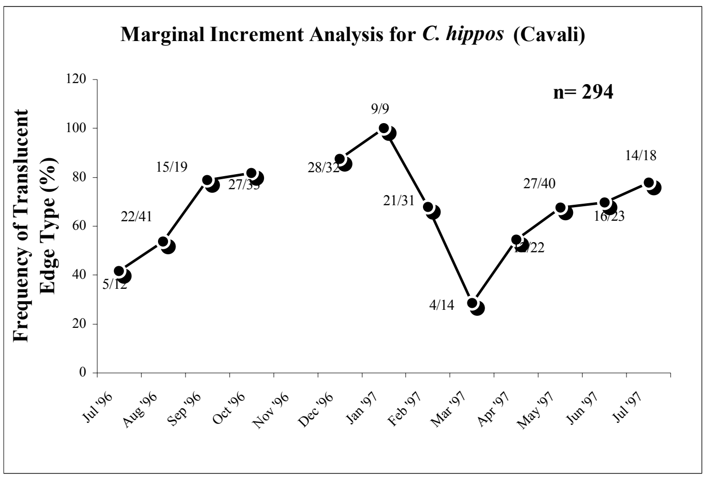


Figure 19. Marginal increment analysis of *Caranx hippos* from Trinidad.

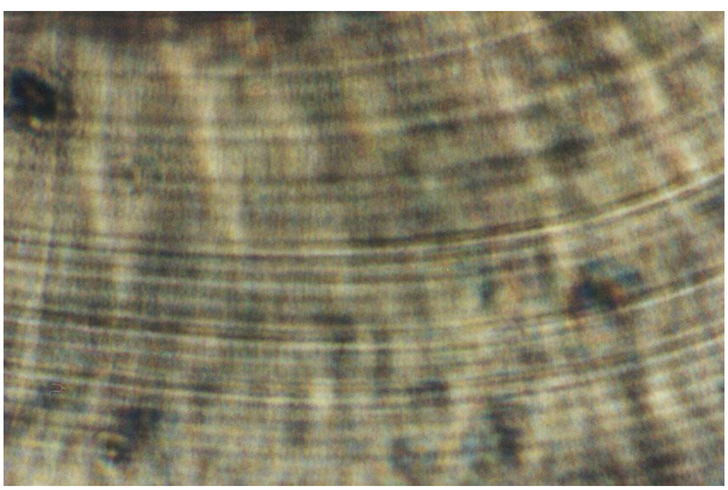


Figure 20. Daily increments on lapillus of *Scomberomorus brasiliensis* from Trinidad. Each increment comprises both dark and light bands.

Working Document: CFRAMP PRFA/2000-09

Requirements for Doing Quantitative Fish Stock Assessment Using Tools Readily Available on the WEB

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Introduction

In recent years, with the increase in fisheries resource exploitation, world fisheries production has plateaued and in some cases may be in decline (FAO website, 1999). The need to accurately predict the extent of and effectively manage exploited (and exploitable) stocks has been the major focus of fish biologist and management experts for almost forty years. Possibly nowhere is that need more pressing than in tropical fisheries which are exploited by the larger percentage of the world's population (UN website, 1999), and where the dependence on fisheries resources as a primary source of protein is the highest (FAO website, 1999).

Most of the fisheries models that have been developed have been for temperate fish stocks and temperate ecosystems. The tradition has been for these models to be used to do analysis on tropical stocks that have significantly different environmental factors affecting them. These temperate species models, which were developed for large single species fisheries, are then been applied to tropical multispecies fisheries with little or no attempt to adapt them to the tropical reality. (Gayanilo and Pauly 1997). In recent years, work has been done at the International Centre for Living Aquatic Resources Management (ICLARM) to develop models that are more specific to tropical fisheries. Most of these models have been published in the various ICLARM publications and have been utilized, to various degrees and with varying success, in the Southeast Asian region.

In 1997 an initiative was undertaken between the European Union and African, Caribbean and Pacific (ACP) countries. Entitled *"Strengthening of Fisheries and Biodiversity Management in ACP Countries'",* this initiative attempts to provide fisheries managers in ACP countries with access to some of the tools available to assist with the management of their respective fisheries. Given the recent growth in the availability of computer technology and the capabilities of personal computers, coupled with the relative ease of access to these machines, the project has attempted to provide 50 countries with the computer hardware and software required to assist with management of their individual fisheries. This has made it possible for basic stock assessment to be done within the various management agencies. The initiative has recently been taken one step further to capitalize on the popularity and ease of access to the Internet and the World Wide Web to be used as a forum for the dissemination of and access to information.

Available information and tools

The major focus of this present initiative is to make fisheries and aquatic resources information readily available, especially on the Internet, so as to facilitate the quick access to such information. This information can then be used in the development of effective fisheries management policy for tropical fisheries. As a part of the initiative, information is made available in one of two ways:

1) Through the FishBase Project. FishBase is a comprehensive database of fish and fisheries information that attempts to document taxonomy, life history, biology and population dynamics of all the known fish species in the world. The database is built on the Microsoft Access database management software. The interface allows users to access the information from different starting points, such as country, common and scientific names. The database is available in two formats, a CD-ROM and an Internet version. For the purposes of this working document the focus will be on the Internet version of the software since it contains interactive routines that can be used to calculate species-specific life history parameters. Additionally, the CD-ROM version will eventually be discontinued.

2) Through the various software and models developed by the International Centre for Living Aquatic Resources Management (ICLARM). ICLARM has over the years developed a number of fish stock assessment models, and subsequently software utilizing those and other models, that are used for stock assessment and management. The collaboration of FAO and ICLARM has resulted in the FAO-ICLARM Stock Assessment Tools (**FiSAT**) program (Gayanilo and Pauly, 1997). This program is used to do Modal Progression and Virtual population Analyses, and calculations of parameters such as the coefficient of growth (K) and asymptotic length (L_∞). There is the program **ABee**, used for the calculation of the two coefficients, a and b, that are in the length-weight relationship equation where the weight W of a fish has a relationship to the length L through the following:

$$\mathbf{W = aL^b}.$$

There is also the program EcoPath which is used to model ecological relationships in various aquatic environments. However, because of the parameterizations required for using EcoPath and the difficulty in obtaining some of them, this software will not be considered any further in this document. Finally there are two spreadsheet routines that are used to calculate the various growth parameters (some of which are listed above) and to do quick stock assessment analyses.

Requirements for accessing and using the tools

With the recent growth in the availability of computer technology, all the Fisheries Divisions in the region have in their possessions or have access to personal computers. Once thought to be inadequate for the types of analyses necessary for fish stock assessment, Personal Computers have significantly improved in processing capability and are now able, with the appropriate software, to handle most of the data manipulation associated with most stock assessment routines. However, there are minimum requirements for accessing and using the software that is available. These requirements are:

An Intel Pentium ® or AMD K-6 ® processor running at 150 MHz
32 megabytes of Random Access Memory (RAM)
2 gigabytes of primary Hard Drive space.
Windows 95/98/NT operating system
Microsoft Excel 97 spreadsheet program
Internet browser such as Netscape or Internet Explorer version 4.0 or higher
Connection to the Internet, either through a direct (Local Area Network) or a dial-up connection (Internet Service Provider). If a dial-up connection is used, a 28.8 kbps (kilobits per second) modem should be considered as the minimum.

For anyone hoping to use the tools, knowledge of how the models were developed and how they function would be an advantage. There are various publications that deal with the development and use of models for fish stock assessment. Most of them are readily available in the fisheries literature but in the event that the user is at a loss about where to start, the FiSAT Reference Manual is being recommended.

Accessing and Using the Software

The first, and possibly, most basic requirement for making use of these pieces of software, is access to a personal computer. The minimum requirements for such a computer is given in the section above. The next basic requirement is access to the Internet. For the remainder of this paper it will be assumed that those two requirements have been met. Once connection has been made to the Internet, the browser should be pointed to the URL www.fishbase.org. This can be done in two ways:

(i) by typing it directly into the browser's ***Location*** window. See **Figure la**.

(ii) by selecting **File** from the browser's menu bar and selecting **Open** from the **File** sub-menu, then typing into the **Open Page** dialogue box and pressing the enter key or clicking on the **OPEN** button. See **Figure 1b**.

The first screen that users see when they connect to the FishBase website is the home page (Figure 2). For the purposes of this paper the important links on that screen are the **Useful links** and the **Search FishBase** links. The FishBase database is accessed online through the Search FishBase link and the Useful links allows access to the programs and routines developed to help with analysis and stock assessment.

FishBase interactive tools

The FishBase database allows the user to access the information in different ways. The two most convenient are to use either a common name or the scientific name of the fish for which information is being sought. The user first follows the **Search FishBase** link to the search form. See Figure 3. Once in the search form, the search for data on the required species is done by using either the common or scientific name of the fish. If the common name is used to start the search, search results will be in the form of a list of species that are known by that common name and the countries where that common name is used. By selecting the species that the user is interested in from the list, information on that species is obtained from the database. If the scientific name is used to start the search then the information on that species is obtained from the database immediately. The primary screen for each species contains general information about the species with links to the more detailed information (Figure 4).

The **Key Facts** link is the one that allows access to the interactive screens. This link brings up an interactive screen that has length-frequency based population dynamics for the species selected (Figure 5). The information presented in this screen is the result of analysis done for that particular species using all the available published information for that species from within the database. Because the screen is interactive and the calculations are real time, the user can change the numbers and view the results.

Parameters such as asymptotic length, L_{∞}, unique to the local population, need to be estimated prior to using the models in this form since the results shown on this screen are calculated using information from the global population. Parameters are entered into the appropriate text box and the Recalculate buttons are clicked. The program then calculates new values based on the parameters replaced. The list of parameters calculated by the model and the variables used in those calculations appear in the left-hand column of Figures 5 & 6. The first-time user should change a range of values to get a feel for how the models work.

The extent to which this interactive tool is helpful depends on three main factors, (i) the speed of the Internet connection, (ii) the amount of Internet traffic and (iii) the accuracy of the values for those parameters that have to be calculated before-hand.

Downloadable tools

The other stock assessment tools available from the Web are programs and spreadsheet routines that need to be downloaded from the FishBase website. These tools can be accessed by following the **Useful links** link and then following the **Downloads** link. This brings up a table with a list of files available, a description and a size for each file. By clicking on the required file, and following the resulting instructions, the files are downloaded to the users computer. The files are compressed to reduce the size and transfer time.

ABee is a Microsoft Windows program that takes an input of values of length an corresponding weights for samples of a particular species of fish and calculates the coefficients a and b that best fits that sample. The program is in the form of a self-installing .exe file. that automatically extracts and installs the ABee program to the users hard drive. Because it comes with online help and a readme file, no attempt will be made here to provide the user with instructions on how to use this program.

LF_Analysis.xls, is a Microsoft Excel 97 spreadsheets that calculates yield potential and Z, F and E for a particular species and population (**Figure 7**). This worksheet is used in conjunction with information on the selected species available from the FishBase **Key Facts** page relevant to that species. The theory behind the calculations done in the spreadsheet and the models used are available in the file Key Fact.exe also available for download from the same location.

PopdynEN.xls and **PopdynJFB.xls** are two spreadsheets that calculate the following parameters for a selected species:

Optimum length (L_{opt}) from length at first maturity (L_m)
Asymptotic length (L_{∞}) from maximum length (L_{max})
Length at first maturity (L_m) from asymptotic length (L_{∞})
Optimum length (L_{opt}) from asymptotic length (L_{∞})
Asymptotic length (L_{∞}) from maximum length (L_{max})
Length at first maturity (L_m) from asymptotic length (L_{∞})
Optimum length (L_{opt}) from asymptotic length (L_{∞})
Natural mortality (M) from growth parameters and mean annual water temperature (T)
Parameters of the von Bertalanffy Growth Function (VBGF) in comparative growth analysis
Population food consumption (Q/B)
Estimation of gross food conversion efficiency (GE)
Relative yield per recruit (Y'/R) as a function of growth, mortality, and length at first capture

The instructions for use, the theory behind the equations used and the models employed to obtain the answers are all included in the spreadsheets.

FiSAT is a DOS-based software package that is designed to perform various types of analyses associated with fish stock assessment. The program is designed to do length-based analysis. It is the result of an agreement between FAO and ICLARM to develop stock assessment software for the microcomputer that would be used by fisheries scientist working in tropical fisheries. (Gayanilo and Pauly, 1997). The software comes with an instruction and a reference manual. Access to the downloadable version of FiSAT is through the trawlbase link on the ICLARM page (www.cgiar.org/iclarm). The files are zipped in such a way that extraction is to three diskettes that are then used to do the installation.

Conclusion

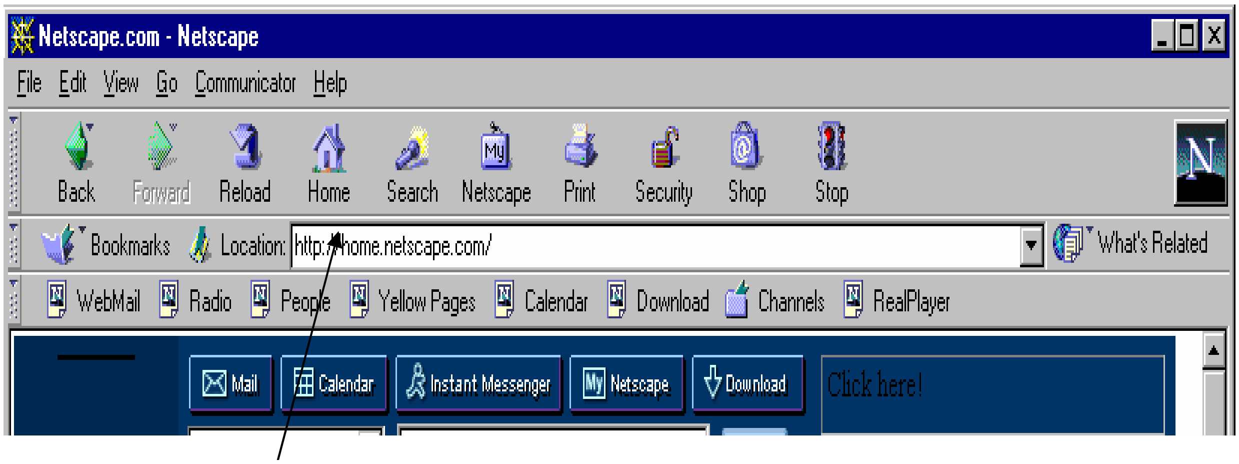
Because of the ease of use of the tools that were described, it may be felt that a rather simplistic view is being taken of data analysis and fish stock assessment. For this reason the following should be kept in mind:

a) These tools should be seen as helping to provide a quick snapshot of the state of a fishery resource. They provide numbers that can and should be used as the bounds for more in-depth analysis of a resource.

b) The tools (as with any tool) were designed primarily as time and labour-saving devices.

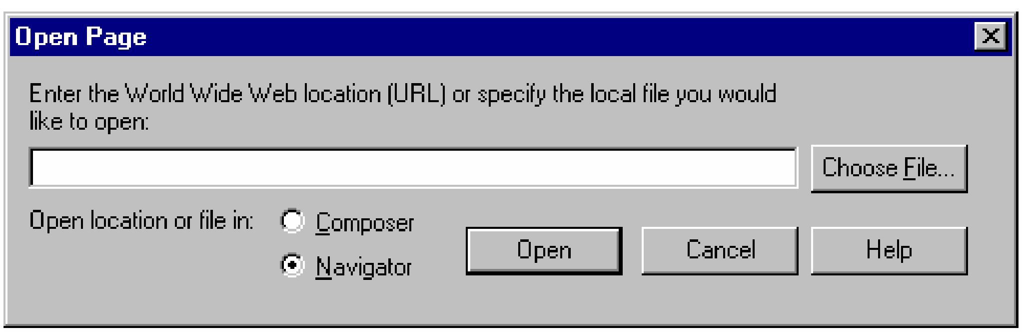
c) Mathematical models on a whole are an attempt to predict behaviour of some natural population or system and will have its uncertainties and errors. Therefore, as with any other tool, they should be used with the limitations kept clearly in mind.

What should also be borne in mind is the fact that in the absence of such tools the process of fisheries data analysis is much more labour intensive and time consuming. In most of the Caribbean Fisheries Divisions time, labour and human resources are scare commodities. Anything that would help to conserve and maximize the efficiency of any of these should be given a second look



Location Window

Figure 1a



Open Page dialogue Box

Figure 1b

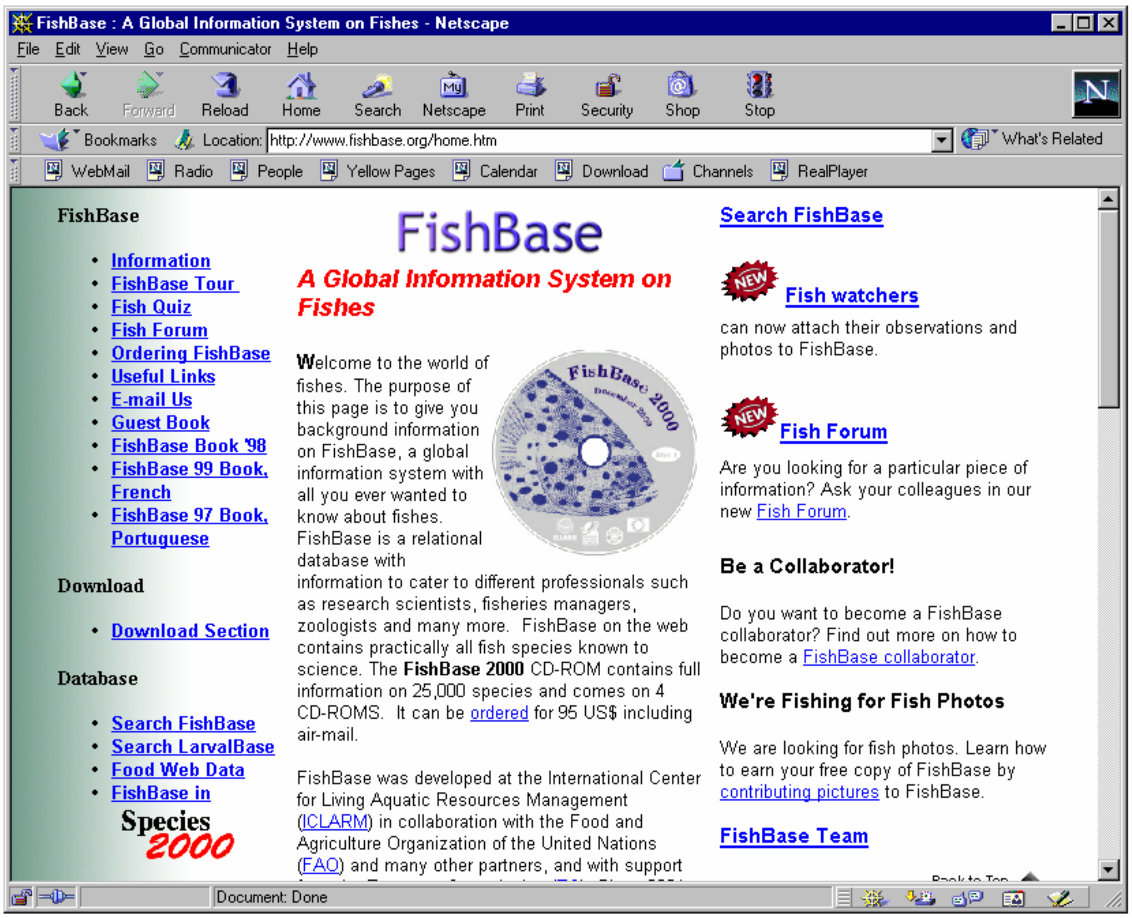
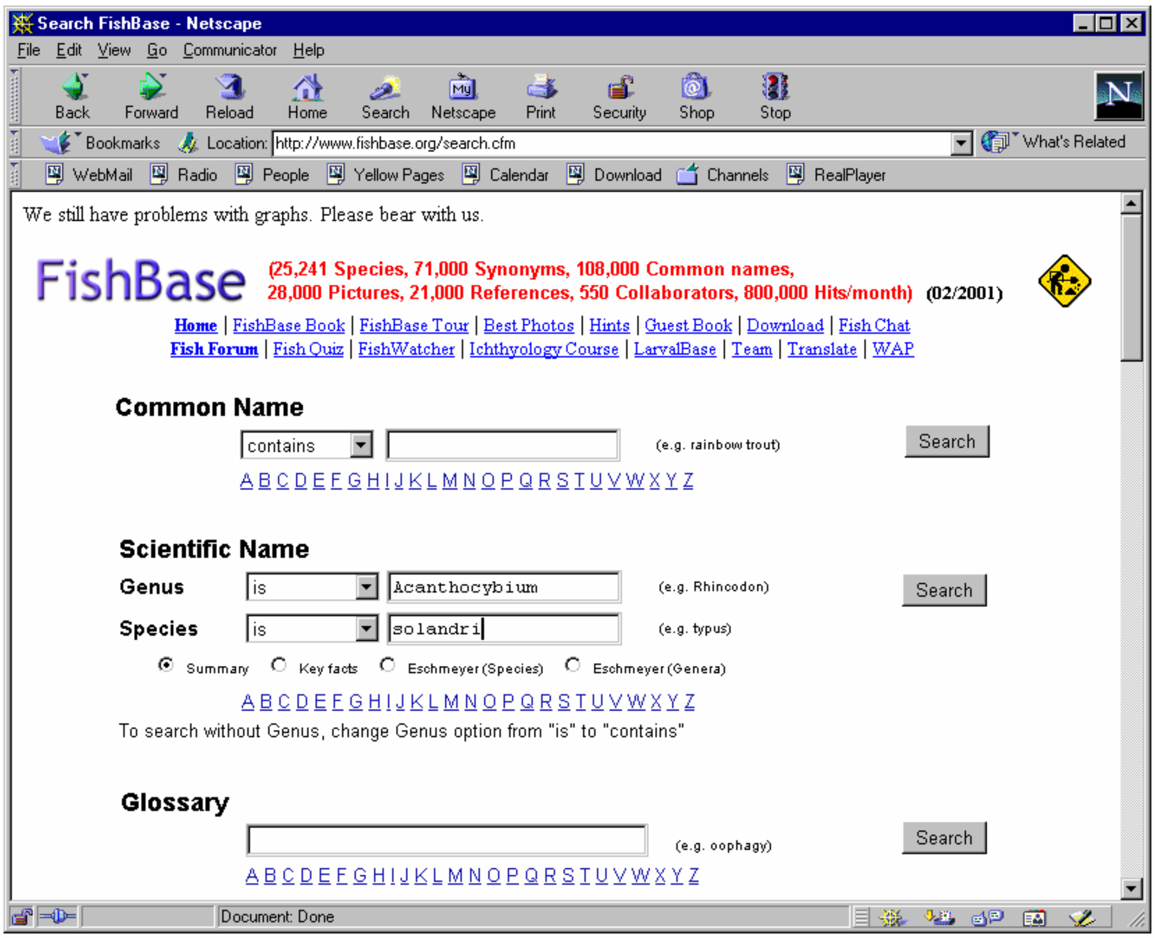

FishBase : A Global Information System on Fishes - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Shop Stop
Bookmarks Location: http://www.fishbase.org/home.htm
What's Related
WebMail Radio People Yellow Pages Calendar Download Channels RealPlayer
FishBase
Information
FishBase Tour
Fish Quiz
Fish Forum
Ordering FishBase
Useful Links
E-mail Us
Guest Book
FishBase Book '98
FishBase 99 Book, French
FishBase 97 Book, Portuguese
Download
Download Section
Database
Search FishBase
Search LarvalBase
Food Web Data
FishBase in
Species 2000
FishBase
A Global Information System on Fishes
Welcome to the world of fishes. The purpose of this page is to give you background information on FishBase, a global information system with all you ever wanted to know about fishes. FishBase is a relational database with information to cater to different professionals such as research scientists, fisheries managers, zoologists and many more. FishBase on the web contains practically all fish species known to science. The FishBase 2000 CD-ROM contains full information on 25,000 species and comes on 4 CD-ROMS. It can be ordered for 95 US$ including air-mail.
FishBase was developed at the International Center for Living Aquatic Resources Management (ICLARM) in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and many other partners, and with support
Search FishBase
NEW
Fish watchers
can now attach their observations and photos to FishBase.
NEW
Fish Forum
Are you looking for a particular piece of information? Ask your colleagues in our new Fish Forum.
Be a Collaborator!
Do you want to become a FishBase collaborator? Find out more on how to become a FishBase collaborator.
We're Fishing for Fish Photos
We are looking for fish photos. Learn how to earn your free copy of FishBase by contributing pictures to FishBase.
FishBase Team
Document: Done

Figure 2


Search FishBase - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Shop Stop
Bookmarks Location: http://www.fishbase.org/search.cfm
What's Related
WebMail Radio People Yellow Pages Calendar Download Channels RealPlayer
We still have problems with graphs. Please bear with us.
FishBase
(25,241 Species, 71,000 Synonyms, 108,000 Common names, 28,000 Pictures, 21,000 References, 550 Collaborators, 800,000 Hits/month) (02/2001)
Home | FishBase Book | FishBase Tour | Best Photos | Hints | Guest Book | Download | Fish Chat
Fish Forum | Fish Quiz | FishWatcher | Ichthyology Course | LarvalBase | Team | Translate | WAP
Common Name
contains
(e.g. rainbow trout)
Search
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
Scientific Name
Genus
is
Acanthocybium
(e.g. Rhincodon)
Search
Species
is
solandri
(e.g. typus)
Summary Key facts Eschmeyer (Species) Eschmeyer (Genera)
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
To search without Genus, change Genus option from "is" to "contains"
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(e.g. oophagy)
Search
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
Document: Done

Figure 3

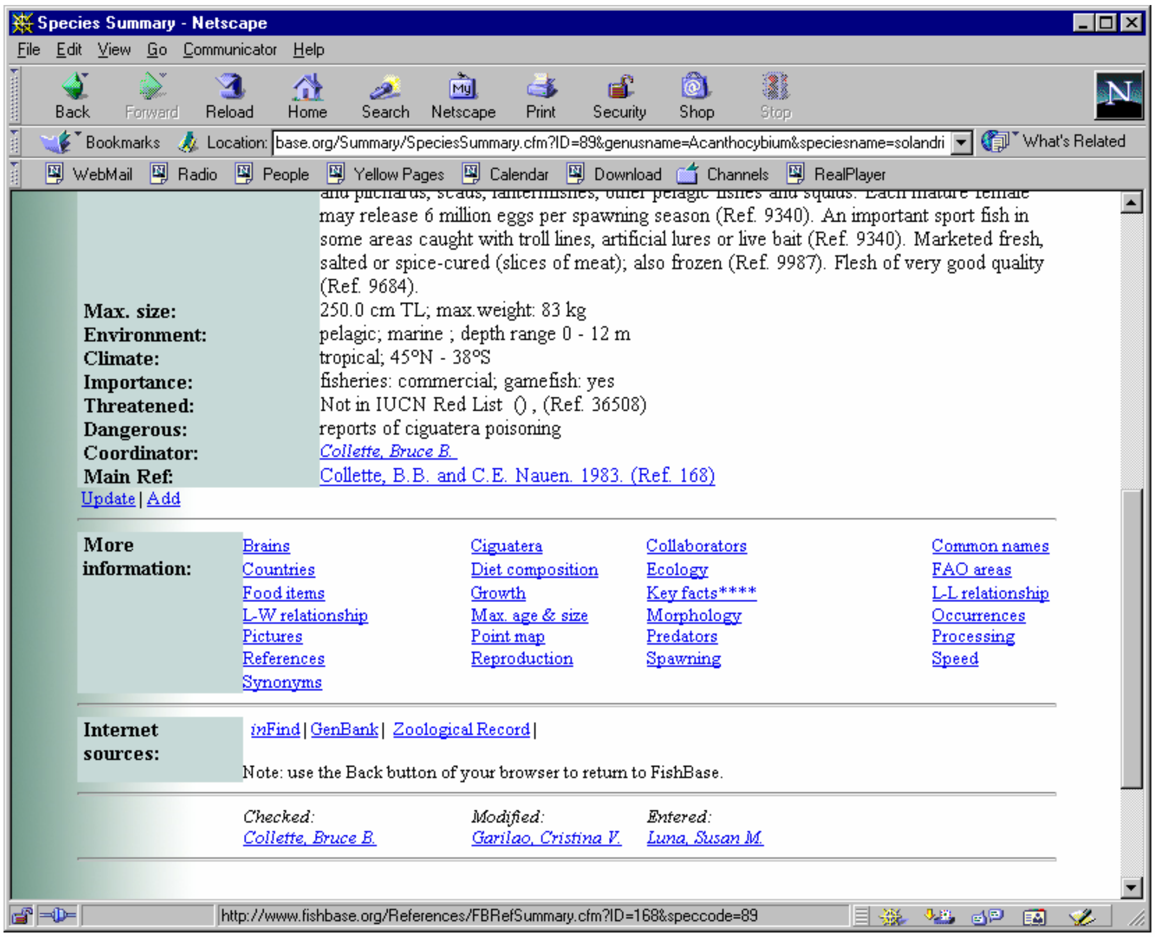
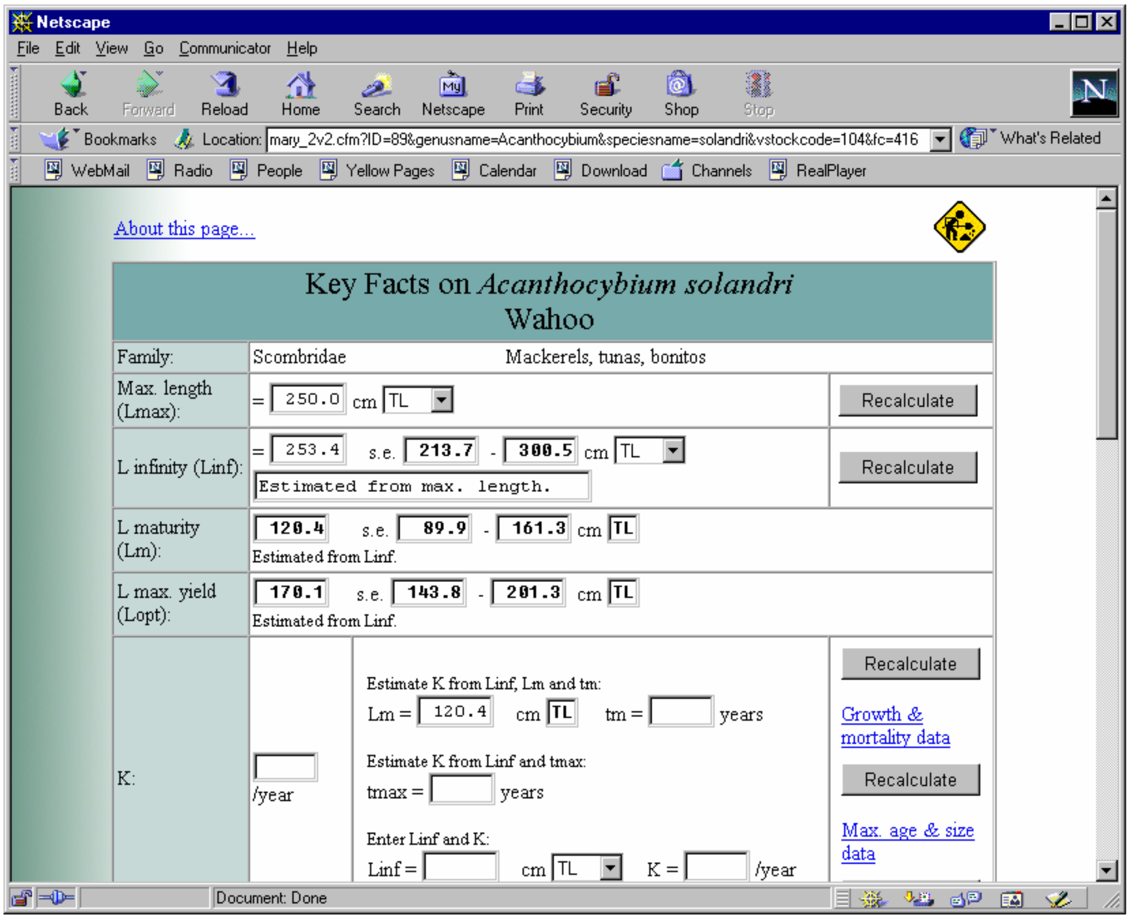

Species Summary - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Shop Stop
Bookmarks Location: base.org/Summary/SpeciesSummary.cfm?ID=89&genusname=Acanthocybium&speciesname=solandri What's Related
WebMail Radio People Yellow Pages Calendar Download Channels RealPlayer
may release 6 million eggs per spawning season (Ref. 9340). An important sport fish in some areas caught with troll lines, artificial lures or live bait (Ref. 9340). Marketed fresh, salted or spice-cured (slices of meat); also frozen (Ref. 9987). Flesh of very good quality (Ref. 9684).
Max. size: 250.0 cm TL; max.weight: 83 kg
Environment: pelagic; marine ; depth range 0 - 12 m
Climate: tropical; 45°N - 38°S
Importance: fisheries: commercial; gamefish: yes
Threatened: Not in IUCN Red List (), (Ref. 36508)
Dangerous: reports of ciguatera poisoning
Coordinator: Collette, Bruce B.
Main Ref: Collette, B.B. and C.E. Nauen. 1983. (Ref. 168)
Update | Add
More information: Brains Ciguatera Collaborators Common names Countries Diet composition Ecology FAO areas Food items Growth Key facts**** L-L relationship L-W relationship Max. age & size Morphology Occurrences Pictures Point map Predators Processing References Reproduction Spawning Speed Synonyms
Internet sources: inFind | GenBank | Zoological Record |
Note: use the Back button of your browser to return to FishBase.
Checked: Collette, Bruce B. Modified: Garilao, Cristina V. Entered: Luna, Susan M.
http://www.fishbase.org/References/FBRefSummary.cfm?ID=168&speccode=89

Figure 4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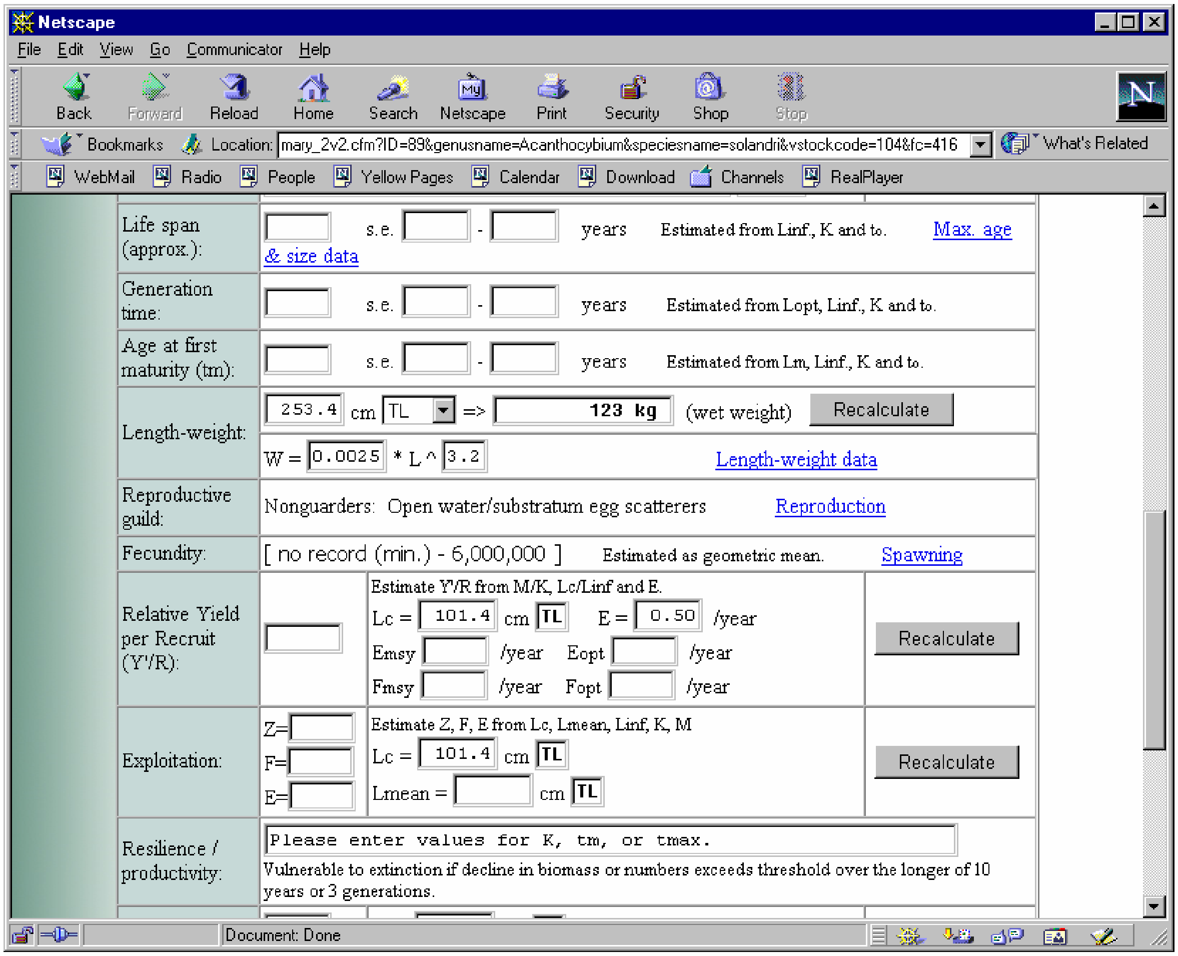
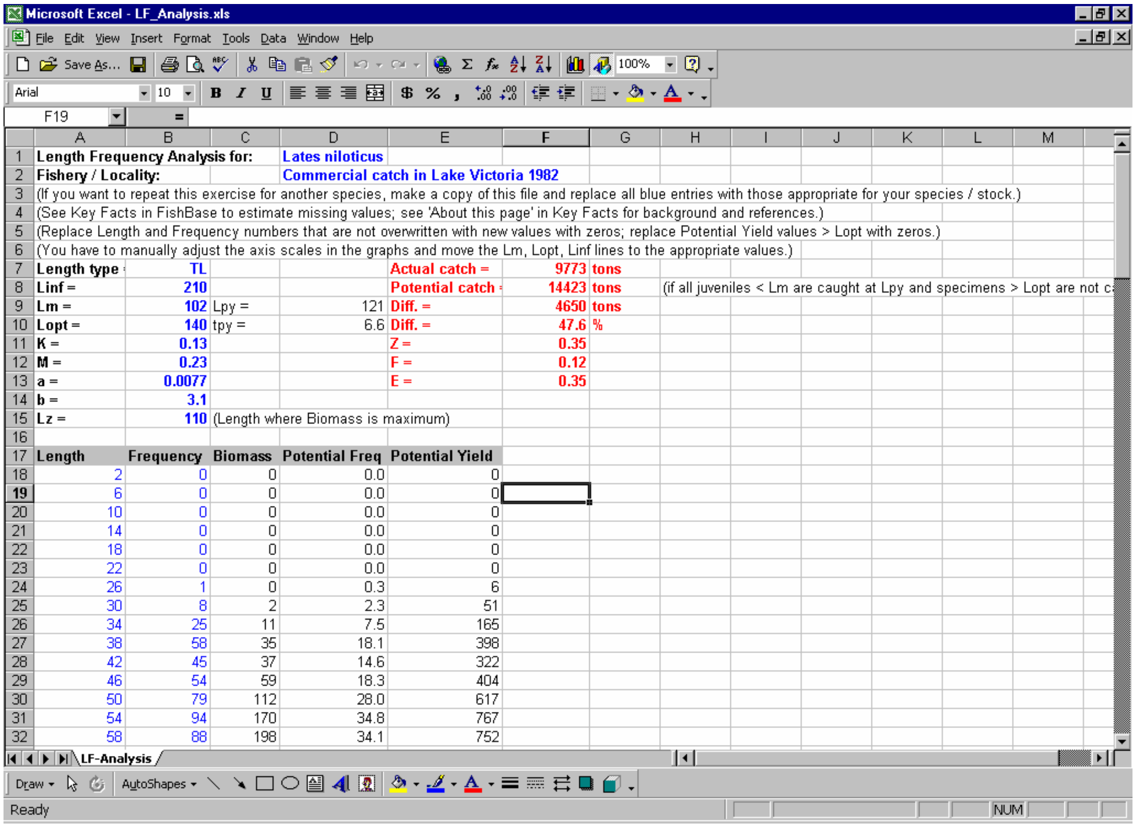
Bookmarks Location: mary_2v2.cfm?ID=89&genusname=Acanthocybium&speciesname=solandri&vstockcode=104&fc=416
What's Related
WebMail Radio People Yellow Pages Calendar Download Channels RealPlayer
About this page...
Key Facts on Acanthocybium solandri
Wahoo
Family: Scombridae Mackerels, tunas, bonitos
Max. length (Lmax): = 250.0 cm TL
Recalculate
L infinity (Linf): = 253.4 s.e. 213.7 - 300.5 cm TL
Estimated from max. length.
Recalculate
L maturity (Lm): 120.4 s.e. 89.9 - 161.3 cm TL
Estimated from Linf.
L max. yield (Lopt): 170.1 s.e. 143.8 - 201.3 cm TL
Estimated from Linf.
K:
/year
Estimate K from Linf, Lm and tm:
Lm = 120.4 cm TL tm = years
Estimate K from Linf and tmax:
tmax = years
Enter Linf and K:
Linf = cm TL K = /year
Recalculate
Growth & mortality data
Recalculate
Max. age & size data
Document: Done

Figure 5



Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Netscape Print Security Shop Stop
Bookmarks Location: mary_2v2.cfm?ID=89&genusname=Acanthocybium&speciesname=solandri&vstockcode=104&fc=416
What's Related
WebMail Radio People Yellow Pages Calendar Download Channels RealPlayer
Life span (approx.):
s.e. - years Estimated from Linf, K and to.
Max. age & size data
Generation time:
s.e. - years Estimated from Lopt, Linf, K and to.
Age at first maturity (tm):
s.e. - years Estimated from Lm, Linf, K and to.
Length-weight:
253.4 cm TL => 123 kg (wet weight) Recalculate
W = 0.0025 * L ^ 3.2
Length-weight data
Reproductive guild:
Nonguarders: Open water/substratum egg scatterers
Reproduction
Fecundity:
[no record (min.) - 6,000,000] Estimated as geometric mean.
Spawning
Relative Yield per Recruit (Y'/R):
Estimate Y'/R from M/K, Lc/Linf and E.
Lc = 101.4 cm TL E = 0.50 /year
Emsy /year Eopt /year
Fmsy /year Fopt /year
Recalculate
Exploitation:
Z= F= E=
Estimate Z, F, E from Lc, Lmean, Linf, K, M
Lc = 101.4 cm TL
Lmean = cm TL
Recalculate
Resilience / productivity:
Please enter values for K, tm, or tmax.
Vulnerable to extinction if decline in biomass or numbers exceeds threshold over the longer of 10 years or 3 generations.
Document: Done

Figure 6



Microsoft Excel - LF_Analysis.xls

	A	B	C	D	E	F	G	H
1	**Length Frequency Analysis for:**			**Lates niloticus**				
2	**Fishery / Locality:**			**Commercial catch in Lake Victoria 1982**				
3	(If you want to repeat this exercise for another species, make a copy of this file and replace all blue entries with those appropriate for your species / stock.)							
4	(See Key Facts in FishBase to estimate missing values; see 'About this page' in Key Facts for background and references.)							
5	(Replace Length and Frequency numbers that are not overwritten with new values with zeros; replace Potential Yield values > Lopt with zeros.)							
6	(You have to manually adjust the axis scales in the graphs and move the Lm, Lopt, Linf lines to the appropriate values.)							
7	**Length type**	**TL**			**Actual catch =**	**9773**	**tons**	
8	**Linf =**	**210**			**Potential catch**	**14423**	**tons**	(if all juveniles < Lm are caught at Lpy and specimens > Lopt are not c
9	**Lm =**	**102**	Lpy =	121	**Diff. =**	**4650**	**tons**	
10	**Lopt =**	**140**	tpy =	6.6	**Diff. =**	**47.6**	**%**	
11	**K =**	**0.13**			**Z =**	**0.35**		
12	**M =**	**0.23**			**F =**	**0.12**		
13	**a =**	**0.0077**			**E =**	**0.35**		
14	**b =**	**3.1**						
15	**Lz =**	**110**	(Length where Biomass is maximum)					
16								
17	**Length**	**Frequency**	**Biomass**	**Potential Freq**	**Potential Yield**			
18	2	0	0	0.0	0			
19	6	0	0	0.0	0			
20	10	0	0	0.0	0			
21	14	0	0	0.0	0			
22	18	0	0	0.0	0			
23	22	0	0	0.0	0			
24	26	1	0	0.3	6			
25	30	8	2	2.3	51			
26	34	25	11	7.5	165			
27	38	58	35	18.1	398			
28	42	45	37	14.6	322			
29	46	54	59	18.3	404			
30	50	79	112	28.0	617			
31	54	94	170	34.8	767			
32	58	88	198	34.1	752			

LF-Analysis

Figure 7

Working Document: CFRAMP_PRFA/2000-10

Descriptive Analysis of the *Opistonema oglinum* (Atlantic thread herring) on the South Coast of Jamaica

Rapporteurs: S. Grant[1], J. Gordon[2] & S. Singh-Renton[3]

[1]CARICOM Fisheries Unit, Belize, C.A.; [2]Fisheries Division, Kingston, Jamaica, W. I.; [3]CARICOM Fisheries Unit, St. Vincent and the Grenadines, W.I.

Introduction

Background

The Atlantic thread herring (*Opisthonema oglinum*) (Le Sueur, 1818) is a marine fish of the family Clupeidae. The species occurs only in the western Atlantic and Eastern Pacific Oceans, mainly in tropical and sub-tropical waters (Hilbebrand, 1963). They are characterized by a filamentous elongation of the last ray of the dorsal fin, a row of scutes along the ventral mid-line, scale rows crossing the back between the head and dorsal fin and an elliptical thin-walled gizzard.

Opisthonema oglinum occurs from Brazil to Massachusetts, including Bermuda, the Gulf of Mexico and the West Indies. They are pelagic in marine coastal waters, seldom occurring in depths greater than 90m and are most abundant in depths of 5-35m (Klima, 1971), but in some seasons larger individuals may be found very near to the bottom. Generally they occur in schools. These fish are seasonal spawners having only one spawning period per year during March to July/August. Data on fecundity, gonad indices, preliminary ova diameter measurements, and length frequency, suggest evidence of several year classes spawning together (Harvey, 1986).

History

Munro (1983) reported intense fishing pressure on the traditional reef fisheries of Jamaica. This, coupled with the fact that the stocks receive little or no replenishment from other areas and rely heavily on the local breeding pool to provide the next generation (Wyatt 1982), have led to a decline in the Jamaican reef stocks. As the reef stocks declined in Jamaica, fishermen have looked to alternative sources of fish. The best alternative investment for the artisanal fisherman was in the exploitation of near-shore species of pelagic fish, especially the clupeoids and scombrids (Goodbody, 1986).

The near-shore or coastal pelagic fishery of Jamaica has therefore become very important, with the Atlantic thread herring comprising 95% of the catch. The thread herring, or sprat as it is locally called, has taken on a cultural significance, being the feature food served for special occasions. Perhaps the most significant uses of the sprat are: (i) the provision of a cheap source *of protein, (ii) contribution to employment, and (iii) provision of bait for other fisheries (eg. offshore pelagics).*

The first island-wide survey for the thread herring was initiated in 1978. The project examined the biology, fishery and management of stocks of certain species of near-shore pelagic fishes and since 1997, the Fisheries Division has collected data on the fishery.

Harvey (1986), back-calculating lengths at earlier ages using fish-scales in combination with length frequency data, suggests that local populations of thread herring may attain a total length of 278 mm ($L\infty$ =203 mm) in 3.5 years. Estimates of total mortality suggest high mortality due to intensive artisanal gill net fishing. Estimated annual total landings of thread herring in Jamaica, together with the source of these data, are noted in table 1.

<u>The fishery</u>

The Atlantic thread herring fishery is an open access, artisanal fishery with little or no management and conservation measures in place. Fishing activities occur around the entire island, but are most concentrated on the south coast (figure 1). Examination of licensing and registration data indicated 14 operational landing sites in 8 parishes where fishers target coastal pelagics. At other landing sites around the country coastal pelagics are taken as by-catch.

The licensing and registration data also confirm that 332 fishers use 110 vessels to fish for small coastal pelagics, but there are others who fish for the resource on a part time basis. The vessels used in the fishery are usually made from fiberglass (8.5m) powered with engines; other vessels used are wooden boats or dugout canoes, which are powered manually by ores or by use of a engine. Most of the catch is used as food or bait. Prices range from J$20 to $40 per pound (US$1=J$37) which is cheaper than reef fish (J$80 - $150 per pound).

<u>Fishing methods and gear</u>

The 1978-82 survey of Guy Harvey showed that gill nets (locally known as the ‘sprat net’) and beach-seines were used island-wide to capture Atlantic thread herring. This is still the case, although the use of beach-seines has decreased drastically over the years. Trammel nets, china nets, handling and lift nets are also used to capture sprat.

The sprat net, consists of multi-filament nylon net, with mesh sizes ranging from 25 mm (1 in) to 51 mm (2 in), floats attached to a head rope, and weights (e.g. bricks or lead) attached to a foot rope. A typical sprat-net is 250 m long by 360 meshes deep, and can weigh in excess of 600 pounds. The most common mesh size used is 44.4 mm (1.75 in). Generally, a crew of 2-3 fishers work on each boat. Vessels depart from the landing sites usually at 3.00-4.00 p.m. and/or at around 1.00-2.00 a.m., in order to travel to the fishing grounds. The deployment of the‘sprat-net’ is similar throughout the country. Once schools of thread herring are seen then the net is set in a straight line across the path of the school. The vessel is then anchored to one end of the net. Sometimes (especially at nights), a lamp is attached at both ends of the net, serving to warn other vessels, as well as to attract the fish. The school is then encircled with the net, and this action forces a large portion of the school to strike the net and become entangled. The net is hauled after 3 to 4 hours, and the fishers return to the landing site. Trammel nets are use in a similar way.

Beach-seines, which are becoming less popular in Jamaica, are also used on a very limited scale to catch thread herring. The fish are encircled and guided ashore where the total catch is hauled onto the beach. The mesh sizes of the net are usually 3 inches at the wings and rapidly increases to 5 inches in other places of the net. Only the smallest of fish can escape this gear. In consequence, the Jamaican government is discouraging continued use of this gear.

Lift nets are also used on a small scale to capture thread herring. Fishers capture fry or bait using lift nets in the Hunts Bay and Kingston Harbour areas. The lift net is allowed to fall horizontally in areas where a school is sighted. As soon as the school of fish moves into the water column immediately above the net, the net is quickly lifted to trap and catch the school.

Fishing ground

The south coast supports most of the small coastal pelagic fisheries. The most productive areas on the Island are Kingston Harbour and the Portland Bight area, which are all located on the south coast of the country (figure 1). The South shelf is about 28 km at its maximum width and approximately 150 km long. The North shelf is very narrow (between 1 and 2 km). Harvey (1986) reported a greater number of Atlantic thread herring on the greater shelf area of the south, and accordingly most directed commercial fishing takes place from beaches located along the island's south shelf. There is one recorded landing site on the narrow north coast of the country.

Data collection programme

In 1997, CFRAMP's Coastal Pelagics and Flying Fish Sub-project provided funds and technical assistance for the development of a data collection programme for the coastal pelagic fishery in Jamaica. The aims of the programme were to:

- improve national accounting of the coastal pelagics fishery on the south shelf of Jamaica
- determine the present status of *Opistonema oglinum*, (Atlantic thread herring) on the south shelf, by comparing present information with past information (Harvey, 1984).

Firstly, a baseline survey was conducted to determine the present status of the fishery in Jamaica. The results of this study were used to develop a data collection programme, which would cover the regular measurement of catch, effort, individual fish lengths and maturity, and social and economic variables. The catch & effort data programme allowed estimation of total landings for the south shelf, which is the main region for thread herring fishing landings: total landings and effort (trip, mesh weight, mesh and hours fished) were recorded at two main landing sites twice a month. Biological sampling (fork lengths, individual weights and sexual maturity) was conducted for a period of 12-18 months, to permit a comparison of the present situation with that observed by Harvey (1984). Some economic data were collected: expenditure and earnings of fishers. Owing to non-cooperation by fishers, the collection of economic data was abandoned. Data were computerised using TIP database software. A number of statistical analyses of the data have been conducted using SPSS and Excel, and the results are presented in the following sections.

Statistical analyses

Length-weight relationship

The individual lengths and weights of 2318 fish were sampled in order to determine the relationship between these two variables, for input into assessment analyses. Assuming an exponential relationship between weight and length of fish, described by: weight = a * length ^{b} , and hence a linear relationship between the logarithms these two variables, i.e. Log (weight) = log (a) + b* log (length), a linear regression was fitted to the log-transformed data (figure 2). The analysis produced the relationship weight = 0.0224 length $^{2.8598}$.

Maturity and spawning

The gonads of 2318 fish (males and females) were examined to determine and classify qualitatively their stages of maturity. Five different stages of maturity were observed: immature, inactive, developing, running, spent. Monthly changes in the sampled frequency of occurrence of the five stages identified are shown for both females (figure 3a) and males (figure 3b). The data suggest that fish are actively spawning during the months of May to November, with the highest frequency of spawning fish occurring in June to July, and a lesser peak in frequency observed in November. Fish that are 'spent', i.e. finished spawning, were also observed in the area during the active spawning months, but in lesser frequencies. Not surprisingly, the frequency of occurrence of fish in 'developing' condition gradually increased in the months leading up to the peak spawning periods of June-July and November. Inactive and immature fish were comparatively more frequent during the months November to May, absent during June-July and less frequent during August to October, providing additional supporting evidence of the peak timing of spawning activities.

Size of fish

Analysis of variance (ANOVA) was used to examine monthly changes in mean fish size. The ANOVA result indicated significant monthly changes in the mean fish size caught ($F=87.5$; $P<0.05$) (figure 4). The highest mean fish length was observed in January, with a second less distinct peak occurring in July. The smallest mean fish length was observed in March. Mean fish size tended to fluctuate about a more or less constant level in other months.

Mean fish length also differed significantly with mesh size ($F=36.7$, $P<0.05$), but the expected simple, consistent positive correlation was not observed (figure 5). The mesh sizes 1.25", 1.5" and 1.75" follows the same pattern reported by Harvey (1996), i.e. the length of fish caught increases with increasing mesh size. Each the 1.37, 1.62 and 1.87 inch mesh sizes used really represents a mixture of mesh sizes within a single net. For example, a net containing a mixture of mesh sizes 1.25 and 1.5 is recorded as a 1.37 inch mesh. The percent contribution of the different mesh sizes to the mixed mesh net is not known, and the different meshes appear to have a specific arrangement with a single net. The observed pattern for the mixed mesh nets deviate from a simple correlation, with the 1.37 inch mesh size taking the largest fish (figure 5). The 1.37 inch mesh somehow provides an optimum mixture and arrangement of the different meshes for capture of larger fish. Given that the greater mesh sizes do not catch correspondingly larger fish, it is possible that larger fish are absent or unavailable to the gear, but further studies are required to confirm this.

Mean landings per vessel trip

The landings per vessel trip differed significantly among gear types ($F=4.657$; $P< 0.05$), with the highest landings per vessel trip observed for the sprat net and hand line gears (figure 6). This result is consistent with the fact that the sprat net is the primary gear, and is appropriately deployed for optimal harvest of these fish. The Atlantic thread herring is taken as a bycatch by other gears. It is not clear, therefore, why hand line gear shows a higher landing per vessel trip than the sprat net; it is possible that the hand line gear may be more selective for larger fish. Factors, such as gear configuration and depth of fishing, are likely to affect selectivity and catchability, and require further investigation in order to explain the observed differences in gear performance.

Catch rates

There were no significant changes in catch per unit of effort (CPUE), measured as kilograms caught per hour fished (kg/hr), with changes in mesh size ($F=0.259$; $P>0.05$) (figure 7), although a mesh size 1.62 inch had a slightly higher mean CPUE than all other mesh sizes. The 1.62 inch mesh also caught the smallest fish observed (see figure 5); it is possible that even though there may be negligible or no age differences, the smallest fish sizes are more abundant and hence greater quantities are caught yielding a higher catch rate. In view of the wide confidence intervals associated with most of the observed means, further studies are warranted.

Examination of monthly changes in CPUE showed no notable differences, although there was a distinct peak in June ($F=2.311$; $P=0.055$) (figure 8). This result is consistent with the fact that the fishery usually targets spawning aggregations. This is further supported by the available data on maturity indices which suggest that fish are actively spawning during June to October, with most spawning effort occurring during June to July (figure 3a & b). The lower CPUE in July may be associated with changes in the size of the spawning aggregations as spawning progresses, such as spent fish moving away from the area, or more probably due to the spawning population having been fished down intensively shortly after its arrival into the area.

GLM analysis estimated the overall mean soaktime (hours the gear is soaking in the water) to be 5.32 hrs. The lowest soaktime occurred during the months of April to June (about 3 hours), associated with fishers' expectation of increasing abundance of fish with the onset of the spawning season (figure 9). The maximum soaktime of 7 hours observed in July probably reflects fisher attempts to maintain catch levels while fish are still concentrated for spawning activities, and as the spawning population is decreased steadily by intensive fishing.

Discussion and conclusions

The southern Jamaica fishery for Atlantic thread herring targets mainly spawning aggregations. As may be expected, therefore, the CPUE in June (the start of the spawning season) was much higher than other months of the year, due to the localised, highest concentrations of spawning fish occurring at that time. There has been recent concern regarding the extent to which recruitment is affected by this directed exploitation of the spawning aggregations, especially given that it is an open access fishery. At present, fishers are forced to stop fishing during certain periods of the year, owing to very low catch rates.

Effective management of this fishery may be possible through application of one or more of the following options: community management, mesh size regulations, catch quotas and or effort limitation. These options have social and economic implications. Community management would require fisher education, and possibly also changes in social attitudes, and infrastructure. A detailed quantitative understanding and assessment of the fishery, as well as continual monitoring of catch rate and biological trends would contribute essential information for determining optimal levels of catch and effort.

Table 1. Annual landings of *O. oglinum* in Jamaica

Year	Landings (MT)	Source
1971	363.8	Russell, 1973
1980	325.0	Harvey, 1984
1983	458.0	Harvey, 1984
1997	399.1	FD, 1997
1998	273.2	FD, 1998
1999	413.8	FD, 1999
Mean	334.7	

Figure 1. Coastal Pelagic Fishing Beaches and Grounds

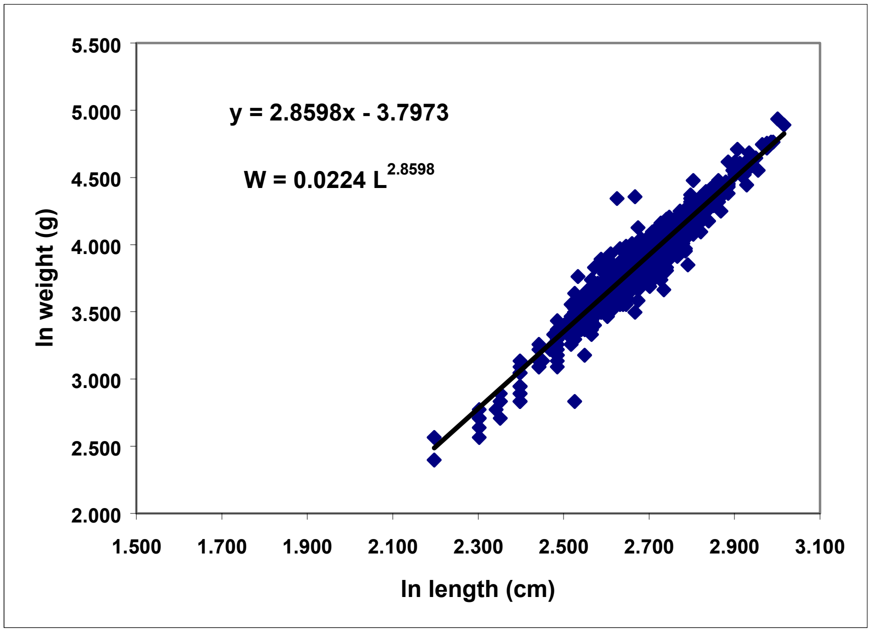
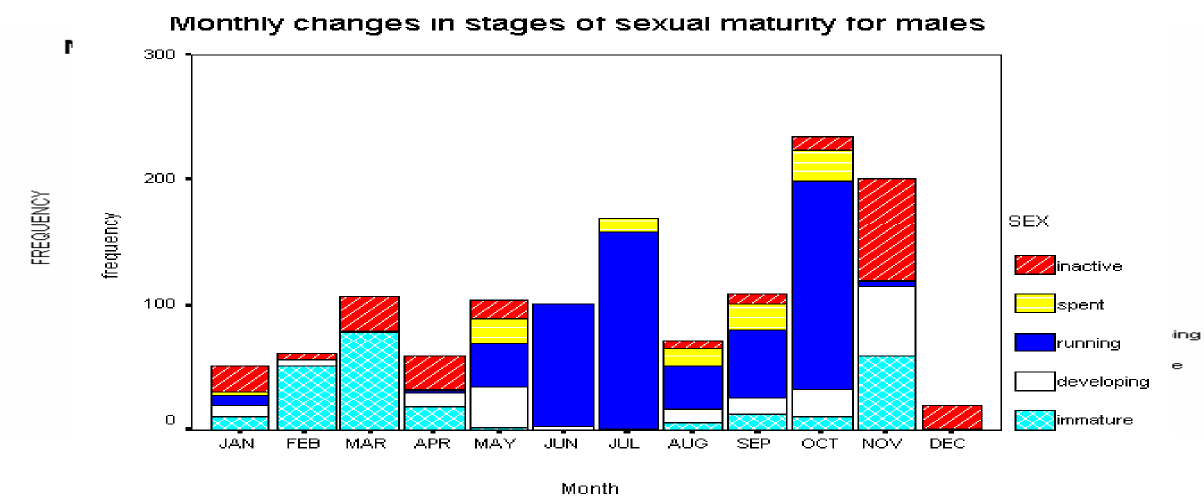


Figure 2. Observed and predicted relationship between log (weight) and log (length).

(a) females



(b) males

Figure 3. Monthly changes in frequencies of maturity indices of (a) female and (b) male fishes.

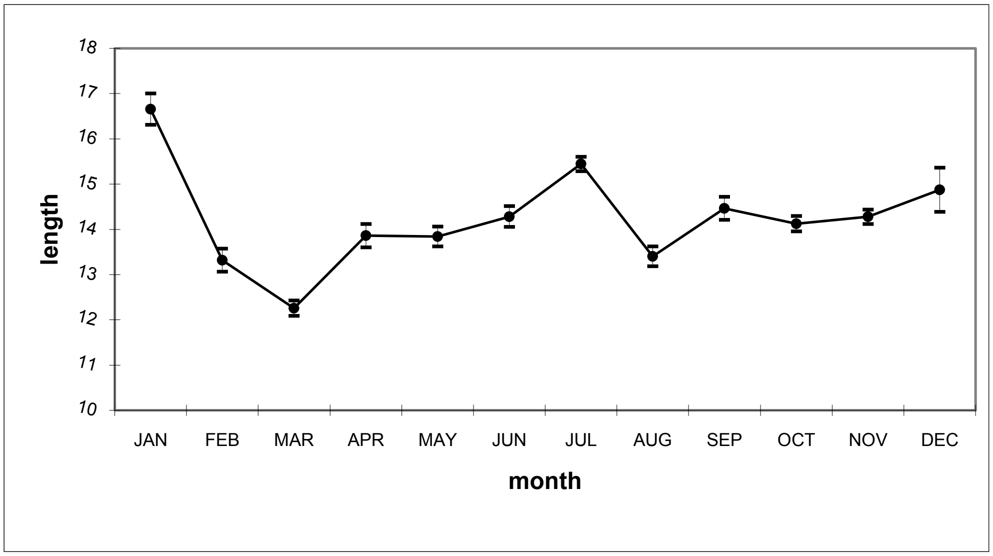


Figure 4. Estimated mean length of fish caught in each month, with 95% confidence limits shown.

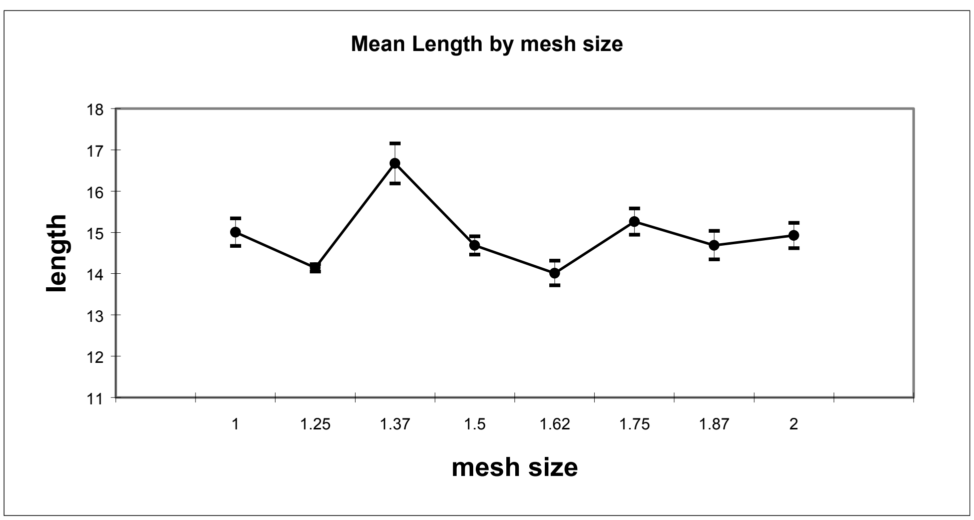


Figure 5. Changes in mean fish size with mesh size.

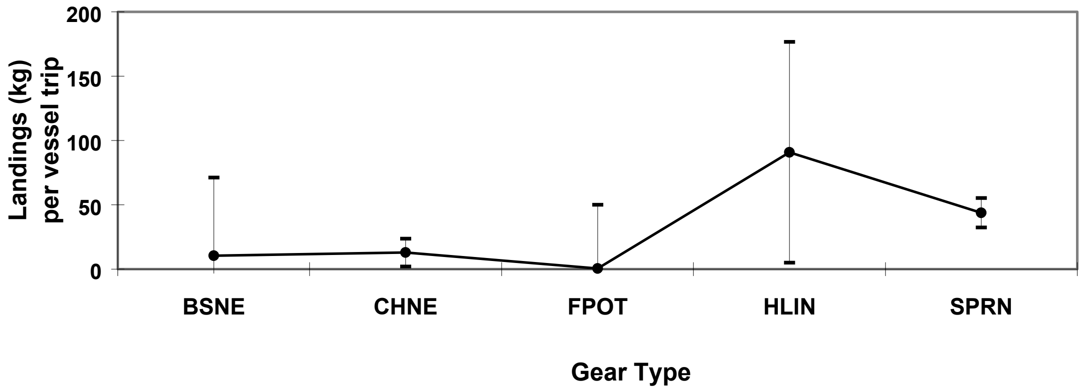


Figure 6. Estimated mean landing per vessel for each gear, with 95% confidence limits shown.

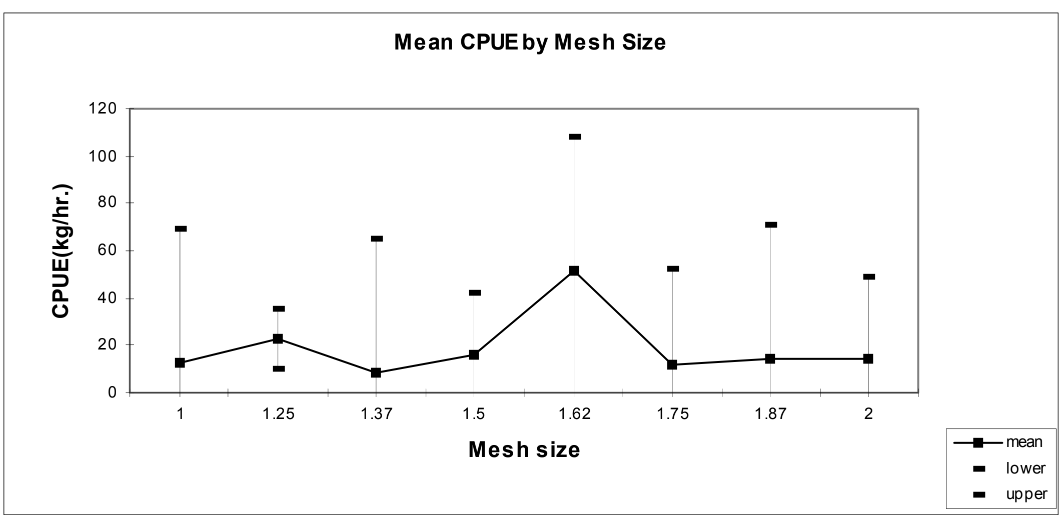


Figure 7. Changes in mean CPUE (kg/hr.) with mesh size.

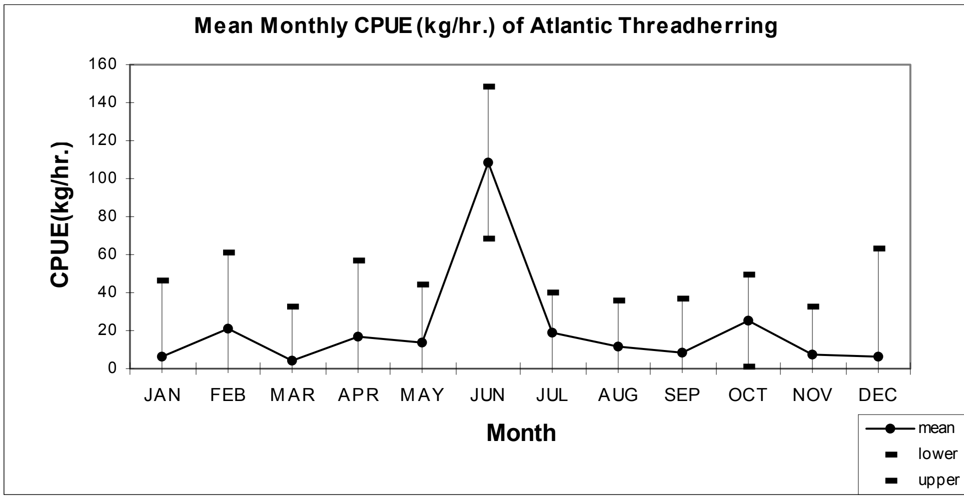


Figure 8. Monthly changes mean CPUE (kg/hr.).

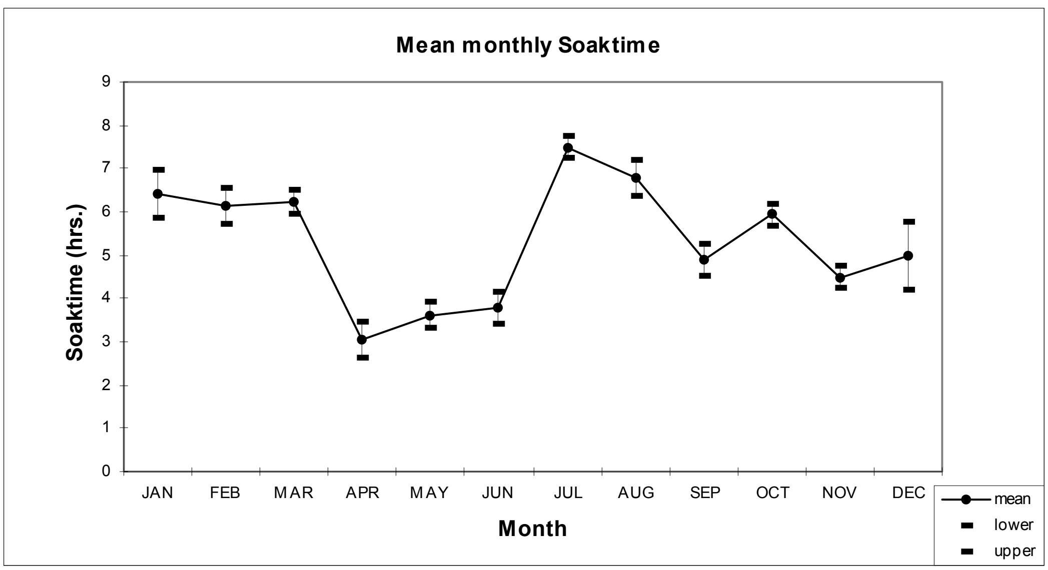


Figure 9. Monthly changes in mean soaktime.

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National Report of Trinidad and Tobago: Pelagic and Reef Fishes - Tobago

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Background

Fishing is an important though relatively underdeveloped industry in Tobago. It is by far the main economic support for many coastal communities around the island. Records from the Marine Resources and Fisheries Department, Division of Agriculture, show that there are thirty-two (32) landing beaches, and ten (10) with fish landing centres. One thousand and thirty-nine (1039) registered fishermen operate six hundred and ninety-four (694) fishing boats (including ten (10) multipurpose fishing vessels), and over sixty-two species of fish and shellfish are caught using eleven different fishing methods. A large proportion of fish caught in the waters of Tobago is processed and marketed locally, regionally, and internationally by ten (10) fish processing plants on the island.

*The fishing activity in Tobago is mainly artisanal and seasonal. In the drifting fishery (or flying fish fishery) snappers, groupers, dolphinfish(*Corypahena hippurus*), wahoo(*Acantobycium solandri*), kingfish(*Scombermorus cavalla*), tuna, billfish and shark are caught. The following fishing methods are used typically: Banking, Trolling, A-la-vive, Drift Longline (palangue), Drifting and Fish Potting. Small open deck vessels 7-9 metres in length, constructed from wood or fibreglass (pirogues/bumboats) make up the majority of the fishing fleet. Outboard engines ranging from-45 – 90 horsepower (HP) propel them. These vessels are usually without modern equipment, communication systems or cold storage facilities (Potts, 1998).*

Introduction

Large pelagics (dolphinfish, wahoo, kingfish (king mackerel) are the second most important type of fish by weight in the drift fishery of Tobago (**Table 1**). The target species (flying fish) accounted for 70-90% of the total landings from major sites during 1988-1994 (Pandohee, 1996). Flyingfish is the preferred bait for catching the high-priced species such as dolphinfish, wahoo and kingfish. These species are processed by several small cottage-type industries and four established processing plants. The final product is mainly packaged as fillets, steaks, salted dried and smoked. The unprocessed product is mainly fresh iced or fresh chilled, frozen whole, and sold on the local and foreign markets. During 1997-1999 one of the large plants exported approximately 9,283 kg of dolphinfish, 1,377 kg of wahoo, 1,272 kg of kingfish valued at US$39,775.11 (**Table 2**).

The large pelagic fishery is mainly seasonal. Dolphinfish is caught between October of one year to August of the next year. Wahoo and kingfish are caught mainly between January and October of each year. During the 'drift' and trolling season, the sale of dolphinfish, wahoo and kingfish is a major source of income to many fishermen. Additionally, employment in the processing plants is a major supplement to the income of many homes; one of the larger plants employs about 50 persons for at least 4 months of the year, i.e. during the 'drift' season (Mohammed, 1996). Collectively, the 4 plants employ about 156 persons for at least 4-6 months of the year.

Dolphinfish, wahoo, and king mackerel are caught mainly using corlene or nylon lines. These lines are floating lines or "drift lines" about 200-300 ft long, with a flyingfish as bait at the end of the hook. Lines are deployed from the stern, bow and port side of the pirogue, the same side with the monofilament-gillnet that is used to catch the flyingfish. Sometimes, these large pelagics come close to the vessel and are caught using a shorter line. This line is called the "little man". A practice called "spranging" is carried out, where the baited line is tossed close to the moving fish and retrieved very fast, thereby teasing it 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" as it is sometimes called, employs about six to seven drift lines or handlines per vessel. This type of fishing is carried out by fishers from the south west of Pigeon Point to the north of Charlotteville. High fish landings and activity are recorded for Pigeon Point and Charlotteville.

Prior to 1995, major landing sites were Pigeon Point, Buccoo Point, Mount Irvine and the Bon Accord Lagoon. There has been increased activity in new areas in recent years: Charlotteville (40 boats), Roxborough (12 boats), Plymouth (22 boats), Granby Bay/Studley Park (22 boats), and Castara (18 boats) and Scarborough (12 boats). CFRAMP funding and support made it possible to commence a catch and effort data collection program covering all these sites. It must be noted, however, that many of these boats do not fish full-time and that a major part of the catch can be attributed to a relatively small number of boats.

A 1991 census indicated that the drift fishery fleet at Buccoo Point, Pigeon Point, and Mt. Irvine consisted of about 75 pirogues and employs approximately 125 fishermen (Samlalsingh, 1996). Today, there are about 126 vessels, 12 of which are iceboats, and employ roughly 228 fishermen. In the absence of an updated boat census, it was not possible to estimate total landings for unrecorded sites and by extension, for the entire "drift" fishery.

Best available data for the period 1988-1999 seasons reported total estimated landings of 215,138 kg dolphin fish, 38,025 kg wahoo, and 51,936 kg kingfish, with a retail value in excess of TT$6,040,957.5. Not much is known about the percentage of exports to the Caribbean or international markets.

Data collection

Data collection now includes the south west Tobago, as well as the north, northeast, and south coasts of the island. In previous years, data have been collected at Castara, Charlotteville, and Speyside. The trolling and a-la-vive fisheries in these areas have re-emerged, with the Charlotteville and Scarborough being the important landing sites for overall recorded landings.

Three landing sites (Pigeon Point 1, Pigeon Point 2, and Buccoo Point) are sampled using a modified data collection sheet. Six other landing sites, (Plymouth, Castara, Charlotteville, Roxborough, Granby/Studley Park, and Scarborough Port) are sampled using a modified beach landing form. The Scarborough fish market data are recorded using a form designed by the Fisheries Department. Data are computerised and copies of the data are sent to Trinidad for validation and analysis by staff of the Marine Analysis limit of the Fisheries Division, Ministry of Agriculture, Land, and Marine Resources.

While there has been a dedicated effort to the collection of the necessary fisheries data, a number of problems remain, and these are listed below:

1. missing data for some months of the year;
2. non-enumeration of all vessels landing during a day;
3. non-enumeration of all landing areas;
4. eye estimates of most of the catches landed were recorded;
5. non-enumeration on Public Holidays and weekends;
6. use of inappropriate data collection forms at times with the associated duplication of data and/or transcription errors;
7. the occasional recording of "second hand" data, i.e. data collectors receiving information the following day via telephone or word of mouth;
8. Data collectors work Monday to Friday from 8:00 a.m. to 4:30 p.m..

At present, data collectors apply a random sampling design for all areas with the exception of the Scarborough and fish market which are normally sampled on a daily basis. Due to the unavailability of funds for additional staff, sampling coverage remains limited to the areas noted.

Fishing techniques

Historically, fishermen did trolling for the pelagic species in wooden boats, and the techniques were learnt from their forefathers. A-la-vive (live bait fishing) is believed to have been learnt from the Venezuelans fishing in our waters to catch these species. "Drifting" or "lurking" was learnt by Tobago fishermen who worked with Barbadians in 1962 (Morschead, per. comm.).

Today, the "drift" and trolling fishery is pursued by about 228 fishermen from approximately 126 pirogues and ice-boats (6-12m in length). Most vessels are made of fibreglass and powered by either outboard gas engines (2 x 30-75 hp), or in the case of the larger vessels, powered by diesel inboard (225-250 hp) engines. The typical crew consists of 1-2 fishermen. The larger vessels carry about 2-3 fishermen and fish for 2-3 days. The pirogues are mainly day boats and fishing starts are early as 6 a.m. until 9 p.m. (10-15 hours).

The trolling season is mainly from late July to early November, and is mainly concentrated in the southwest part of the island at Pigeon Point, Buccoo, and Mt. Irvine. Fishermen between Castara and Charlotteville fish from the head of the island to Sisters Rock from January to December; and fishermen between Speyside, Roxborough, and Studley Park fish between Little Tobago and

Bacolet Point from January to December. Some fish potting is done within the two seasons during the year.

As early as 1995, the collaborative effort of the Japanese and Trinidad and Tobago governments to train fishermen in new techniques have realized the JICA/CFTDI training programme in tuna longline, vertical longline for demersals and the setting of FADs around the island's coast for large pelagics. This has proved successful and training takes place each year.

Employment and income generated by fishing

There are four major processing plants on the island: Tobago Sea Products Ltd.; Jacobs' Enterprises Ltd.; Terry Swan Ltd.; and Fresh Fish Tobago. Collectively, these plants employ about 156 persons (mainly women) who do the processing. The men do packing, weighing, sorting, transporting, and maintenance of the plant and machinery. Though processors do some cold storage of the product, the majority of their storage is held at the NIPDEC facility.

Table 1: Estimated Total Annual Catch (lbs) and Nominal Statistics for the 1988-1999 Fishing Season

SEASON	TRIPS	DOLPHINFISH	WAHOO	KINGFISH
1988	1,339	52,265	0	1,624
1989	1,380	79,996	0	2,720
1990	1,686	47,455	0	1,318
1991	1,192	53,125	207	3,602
1992	1,242	28,400.5	0	4,645
1993	923	21,766	75	7,990
1994	675	25,149	0	2,579
1995	995	44,101	245	1,442
1996	1,085	27,729	0	1,996
1997	2,454	34,181	26,574	20,811
1998	1,813	31,470.5	34,212	32,826
1999	678	27,665	22,341.5	32,837
TOTAL	**15, 462**	**473, 303**	**83, 654.5**	**114, 260**

Table 2. Estimated Exports and Value to Caribbean, USA and UK Countries (Data supplied by Tobago Sea Products Ltd.)

Year	Species	Estimated Total Exports (kg)	Estimated Value TT$(x1000)
1997	Dolphinfish	2 781.05	55 621
	Wahoo	632	12 640
	Kingfish	1 228	24 560
	Total	**4 641.05**	**92 821**
1998	Dolphinfish	4 278	85 560
	Wahoo	427.484	8 549.68
	Kingfish	44	880
	Total	**4 749.484**	**94 989.68**
1999	Dolphinfish	2 224	44 480
	Wahoo	318	6 360
	Kingfish	0	0
	Total	**2 542**	**50 840**

Table 3: Fish Landings Collected and Value for the artisanal fishery in Tobago [dolphinfish, wahoo and kingfish 1988-1999]

1988-1999

Species	Landings (lbs)	Value $TT (x1000)
dolphinfish	440 067	3 960 603
wahoo	3 756	33 804
kingfish	29 292	292 920

Landing Sites: Pigeon Pt; Buccoo Pt; Bon Accord Lagoon; Mt. Irvine.

1997-1999

Species	Landings (lbs)	Value $TT (x1000)
dolphinfish	34 020	306 180
wahoo	73 179	658 611
kingfish	84 857	848 570

Landing Sites: Roxborough; Charlotteville; Plymouth; Castara; Granby/Studley Park; Scarborough Port.

Total for Ten Landing Sites

1988-1999

Species	Landings (lbs)	Value $TT (x1000)
dolphinfish	474 087	4 266 783
wahoo	76 935	692 415
kingfish	114 149	1 141 490

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National Report of St. Vincent and the Grenadines - Dolphinfish *(Coryphaena hippurus)*, Wahoo *(Acanthocybium solandri)*, Red hind *(Epinephelus guttatus)* and Coney *(Cephalopholis fulva)*

by L. Straker[1] and C. Jardine[1]

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Introduction

Since its revision in 1992, the data collection programme in St. Vincent and the Grenadines has made tremendous strides and continues to do so with commendable assistance from CFRAMP. We are pleased with this progress but realize that much work lies ahead. More than 5 years of consistent data have been collected thus far. Information collected from the Licensing and Registration Programme (LRS) provide sociological and economical data on the fisheries, while field sampling programmes have been set up to capture data on catch and effort and biological data. This information can be used in statistical and stock assessment analyses to provide advice on stock status. Charts of the main landing sites on tha mainland and in the Grenadines are shown in Figures 1 & 2.

Dolphin and Wahoo (Trolling/Off-shore pelagics)

The off-shore pelagic fishery is still predominantly artisanal in nature. Dolphin fish *(Coryphaena hippurus)* and wahoo *(Acanthocybium solandri)* are targeted using **trolling** and **longline** methods. The trolling fishery is more extensive, and takes practically all of the landings for these two species. Other species targeted by the offshore fishery include skipjack *(Katsuwonus pelamis)* and bonito (*Thunnus atlanticus).*

Before the 1980s trolling took place from January to July each year. Wooden double-enders measuring an average 20 ft in length, powered by a 30 hp engine and carrying a crew of 3 were used. A notable percentage of the vessels were canoes introduced to St. Vincent from St. Lucia. The main fishing grounds were in the north-east to the south-east side of the island, up to 25 miles off-shore.

Each crew member used up to two lines of approximately 150-180 ft in length; each line carried one hook. The baited line would be hauled behind the boat at a low speed. The fishermen would leave about 4 a.m. and caught bait using a cast-net before going to the fishing grounds. On their way to the grounds, the fishermen would look for birds to help them to locate schools of fish. They would return to base between 2-4 p.m.

This particular technique has not changed much over the years. The main season is still from January to July. Pirogues, constructed from fibreglass, measuring 23 ft, powered by 45 hp engines with a crew of 3 are now used. The canoes and double-enders are no longer a part of the fleet of this fishery. Fishermen now go up to 50 miles off-shore.

Stainless steel No.3 double hooks, baited with artificial lures, are used on troll lines. The line is nylon monofilament usually 80-120 lbs tested. Each fisher uses up to two lines of approximately 150-180 ft in length with each line carrying up to 5 hooks. A stronger gear set-up is used for dolphin and wahoo fishing: stainless steel No. 6-8 straight hooks, with monofilament nylon line, usually 120-160 lbs tested. The lines are usually single hooked double baited with both artificial and real baits at times. When fishing for kingfish a wire-lead is often employed. The length of each line is 120-180 ft but this may vary depending on the schooling behaviour of the fish. When a school of dolphin or kingfish is located the fishermen often deploy markers in the form of buoys or oils. Chumming is also sometimes used. Birds and floating debris are still used as guides in locating and identifying schooling fish. A typical fishing day begins at 4 a.m and ends at 4 p.m.

Red Hind and Coney Fishery

This is a multiple gear, artisanal fishery as fishermen use traps, spear guns and various forms of bottom hand-lining to harvest these species. Bottom hand-line is the predominant gear used. The use of mechanised hauling equipment is being tested. Other species targeted include parrot fishes *(Scaridae)* and grunts *(Pomadosyidae)*. Fishing is conducted throughout the year, with increased effort outside of the dolphin and wahoo season.

Double-enders of about 20 ft in length powered by 6-9 hp outboard engines and equipped with a sail, carrying a crew of 4-5 were used in the past (pre-1980). Today, the boats are usually the same size or bigger, but pirogues are also used with outboard engines of up to 45 hp with a crew of three. A typical fishing day is from 4 a.m to 4 p.m. The catch is usually sold to trading vessels for export to Martinique. The main fishing grounds are the south-east shelf of mainland St. Vincent and the east shelf of the Grenadines in up to 50 meters of water.

The typical handline is 80-120 lb tested, and usually consists of 4-5 baited hooks (No. 7-9 circular galvanized hooks). Small coastal pelagics (e.g robin, jacks, balahoo) are normally used as bait. The fishermen deploy the lines by hand and wait for the fish to strike. Sometimes floating devices are used and the set-up is allowed to soak for several minutes. The palang is a bottom longline, extending up to 300 ft in length and consists of up to 100 baited hooks. This set-up is left to soak for one or two hours before retrieving.

Traps are constructed of chicken wire using wooden frames and are about 2.3 cubic meters in volume. The arrow-head style of trap is most common. Traps are baited with either fruit or fish, and are set at varying depths on the reefs. Soak time may last 5-7 days. Crew size is often one.

Data collection

There are currently 7 data collectors, each responsible for a given landing site zone. The level of infra-structural development at the various landing sites throughout the state has improved significantly during the last 6 years. In 1992 the New Kingstown Fish Market (NKFM) was the only landing site with marketing facilities such as, vending stalls, ice machines, chillers, etc.. Similar facilities now exist in Paget Farm, Bequia; Britannia Bay, Mustique; Friendship, Canouan; Clifton, Union Island; and Calliaqua, St. Vincent. Similar facilities are planned for Barrouallie and Chateaubelair.

The landing sites are zoned and categorized (stratified). There are 7 zones and 36 landing sites (Table 2). A site is designated as primary, secondary or tertiary, based on 3 main variables: the number of fishing boats that regularly land fish at the site; the amount of fish landed; and the level of infra-structural development. There are 2 primary sites (Kingstown and Barrouallie), 14 secondary and 20 tertiary sites. In addition to these on-shore landing sites, several trading vessels take fish directly from the fishermen; for sampling purposes, these vessels are treated as landing sites.

The catch and effort data follows a stratified sampling methodology. In this case we wish to estimate the total number of fish landed in the state. The sampling units (landing sites) are stratified as noted previously. The techniques of simple random sampling is then used to select the days of the month each landing site is sampled. Sampling is not carried out on Sundays and major holidays, although every day is considered a potential fishing day. This simplifies data analysis and does not seem to be a great source of error since fishermen fish whenever they can regardless of what day it is.

An estimate of the amount of fish landed in the country is obtained by summing the totals of all the estimates for the individual landing sites.

Total landings = Estimates (site1 + site2 + site3 + ...)

Estimate for any site = sampled weight x (# of days in month / # of days sampled)

Raising factor (rf) = (# of days in month / # of days sampled)

Estimate for any site = sampled weight x (rf)

Kingstown is the only site at which a total census is carried out, as the fishermen must pay a landing toll for fish landed at this market. This additional information is used as a comparison with data obtained from the sampling programme. Some landings, especially for the low value species (coastal pelagics) are often not recorded. The problem of frequent staff changes also impinges on consistent and accurate data collection at this site.

Fish landings, particularly in the Grenadines, due to activities such as, sale at sea and direct sale to hotels are not captured by the data collection system. There are plans to conduct surveys that will give an estimate of this missing information. To account for non-sampled days, the time of year and landing site zone are recorded, and these two variables are used to provide the best estimate for the missing period, using the recent five year average for the same period. For instance, if landings for Barrouallie are missed for September 1999, then an average of all the Barrouallie landings from 1994-1998, broken down by species, will be used as a best estimate for this missing period.

Current biological data collection involves length measurements of a few selected species at selected landing sites. On St. Vincent, length measurements are carried out at Kingstown, Greathead and Calliaqua. Wahoo, dolphin, red hind and coney are among the species sampled at these sites. In the northern Grenadines, biological sampling is carried out on 3 trading vessels, which are considered as off-shore landing sites. Sampling of red hind and coney are carried out on deck randomly, as the fishermen land their fish.

Exports and imports

Dolphinfish and Wahoo

Export permits and health certificates provide precise information on the composition and weight of species exported. Statistics on the quantity and value of species exported and countries to which fish are exported are produced quarterly. This export figure is cross- referenced with the estimated figures obtained from field sampling to prevent under- or over- estimation of total landings. In all cases the figures try to identify total landings and not total catch. The value of each species exported and landed is usually the current market value at that time when the data are collected (Table 1). Market value fluctuates, depending on supply and demand. Fish import information is recorded by the Ministry of Trade.

Red hind and Coney

Average annual landings for red hind is about 30% higher than that for coney but they generally fetch a steady price of about $5.00 EC per pound on both the local and export markets. Average exports for both species represent about 50% of landings (Table 1).

Policy and Regulations

Dolphinfish and Wahoo

There are no regulations controlling the management of the dolphin fish and wahoo in the eastern Caribbean. However, because they are large pelagics the objectives are to cooperate with members of ICCAT particularly in the Caribbean to assess, protect and conserve these species; and to promote the development of commercial and sport fishing activities with respect to these species.

Red Hind and Coney
Current Regulations include mesh size restrictions; restriction on the use of spear guns, the use of dynamite, poisons and other noxious substances. Trammel nets are prohibited.

Economic information

Dolphinfish and Wahoo
The dolphin and kingfish fishermen do not carry ice. The catch is usually placed in a shaded area of the boat or in a make-shift compartment constructed of flour bags and bamboo. Most of the fish is either sold fresh or chilled on ice at the local markets throughout the state. A small percentage of the fish is blast-frozen when the supply is high, particularly in the peak of the season.

The normal retail price for the two species is EC$5.00/lb. However, this could fall to $EC2.00/lb during glut periods. Table 1 shows details on landings and exports during 1994-1995. Average annual landings of dolphin is about twice that of wahoo but they generally fetch the same price on the local and export markets, about $5.00 and $7.00/lb respectively. Just over 8% of dolphins harvested are exported while about 15% of wahoo are exported.

Red Hind and Coney
The fishermen do not usually carry ice. The catch is placed in a shaded area of the vessel or a container of some kind. The catch is usually sold fresh to the trading vessels or at the local markets where it will be chilled on ice for retailing. There is no significant post-harvesting of these species but a small amount is usually dry salted for local and domestic consumption. The normal retail price for both species is EC$5.00-6.00/lb.

Table 1. Details on landings and export, averaged over 1994-1995.

Species	Average annual landings (lbs)	Value of landings (EC$)	Average annual exports (lbs)	Value of exports (EC$)
Dolphin	117,000 lbs	$590,000.00	9,600 lbs	$65,000.00
Wahoo	63,000 lbs	$315,000.00	9,300 lbs	$62,000.00
Red hind	63,000 lbs	$270,000	31,000 lbs	$130,000
Coney	49,000 lbs	$200,000	26,000 lbs	$125,000

Table 2. Sampling frame (assuming 24 sampling days)

ZONES	LANDING SITES	CATEGORY	DAYS/MONTHS	% SAMPLING
ZONE 1	KINGSTOWN	1	12 / CENSUS	50 / CENSUS
	GREATHEAD	2	6	25
	CALLIAQUA	2	6	25
	INDIAN BAY	3	3	12.5
	LOWMAN□S	3	3	12.5
	QUESTELLES	3	3	12.5
	CAMPDEN PARK	2	3	12.5
ZONE 2	CLARE VALLEY	2	4	16.7
	BUCCAMENT	2	4	16.7
	LAYOU	2	4	16.7
	BARROUALLIE	1	12	50
ZONE 3	TROUMACA	3	3	12.5
	DARKVIEW	3	3	12.5
	ROSEBANK	2	3	12.5
	CHATEAUBELAIR	2	10	41.7
	FITZHUGHES	3	3	12.5
	PETIT BORDEL	3	2	8.3
ZONE 5	BIABOU	3	6	25
	SANDY BAY	3	6	25
	OWIA	3	6	25
	FANCY	3	6	25
ZONE 6	FRIENDSHIP BAY	3	ESTIMATED	
	PAGET FARM	3	ESTIMATED	
	ADMIRALITY BAY	3	ESTIMATED	
	LOWERBAY	3	ESTIMATED	
	LA POMPE	3	ESTIMATED	
	TRADING VESSELS	2	24 DYS/MTH (Random sample)	
	BRITANNIA BAY	2	CENSUS	
ZONE 7	CANOUAN	2	CENSUS	
	CLIFTON	3	CENSUS	
	ASHTON	3	CENSUS	

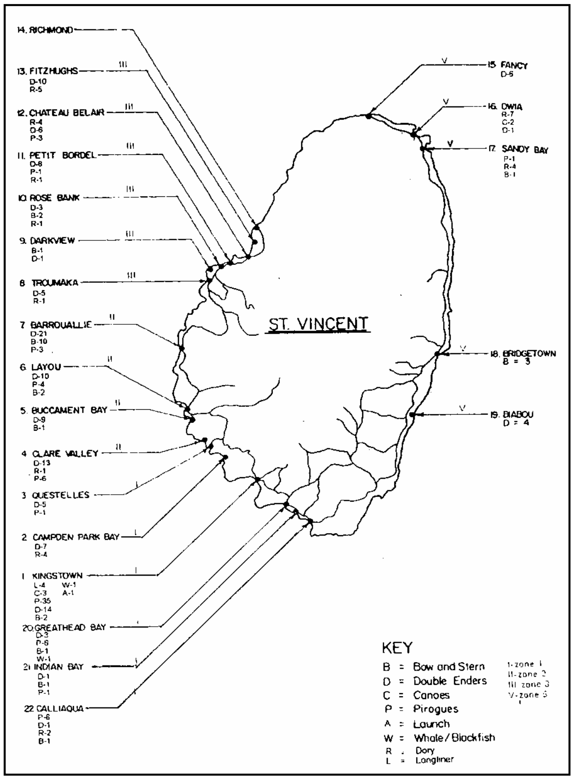

Figure 1. Chart of landing sites in St. Vincent.

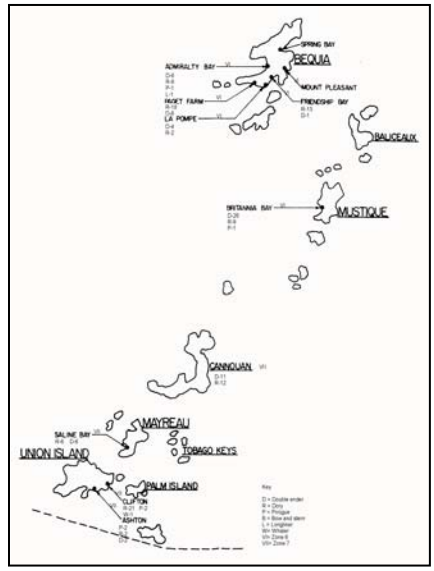

Figure 2. Chart of landing sites in the Grenadines.

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A Description of the Dolphinfish (*Coryphaena hippurus*) Fishery of Barbados

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Description of the fishery

<u>Fishing gear</u>

Historically, the dolphinfish, *Coryphaena hippurus*, has been a major target species for the Barbadian fishermen. Although the fish have always been taken by hook and line, the level of sophistication of this simple gear has improved over the years. In 1942, Dr. H.H. Brown published the first comprehensive report of Barbadian fisheries. Brown explained that dolphinfish were captured with very "crude" gear consisting of "an old rusty hook with a rag or flying fish attached; a leader of any old bit of wire sometimes doubled and redoubled; and a piece of line strong enough to hold only a moderate sized fish (up to say 70 lbs)".

Instead of the crude lines described by Brown (1942), the modern commercial fishermen uses two basic line assemblies, for capturing large pelagics such as dolphinfish. The first of these lines is the trolling line. This includes a main line (approx. 100 m in length) made of either multi-strand or monofilament nylon attached via a barrel swivel to a length (approx. 50 m) of multi-strand stainless steel wire (breaking strain 500-900 lbs). The multi-strand wire is in turn attached by another barrel swivel to around six feet of single strand stainless steel wire (breaking strain 300 lbs) to which the single hook is tied. The hook of choice is a size 9 (#2330 Hi-liner) and of a straight shank, knife-edge and long point design (Willoughby and Leslie, 2000). At the fishing ground the fishermen will deploy a hand held line of basically the same design but shorter and without the length of multi-strand stainless steel wire. This line is referred to as a lurk line.

Sport fishermen, using more sophisticated rod and reel fishing gear, also capture dolphinfish. While commercial fishermen generally still bait their hooks with flying fish, sport fishermen may also use artificial fishing lures.

The last type of fishing gear used to capture dolphinfish is the horizontal long line gear used on local long line vessels. Local long liners use a main line (between 24 to 48 km, in length) to which 200 to 300 shorter lines (12 to 36 m long) are attached. A light stick, fishhook and bait are attached to each of the short lines. The longline is kept afloat by buoys placed at regular intervals along the length of the main line. The lines are usually set late in the evening and hauled just after sunrise the next morning (Willoughby and Leslie, 2000).

Fishing Fleet

Developments in the fishing fleet have probably had a greater impact on the large pelagic fisheries than developments in fishing gear. Three main crucial developments can be identified in the evolution of the Barbadian pelagic fishing fleet. The first major development was the motorisation of the fishing fleet in the 1950’s.

By the early 1950’s sail propelled fishing boats ranged in size between 18' to 24' in overall length, 6' to 8' maximum width, and draught of 4' to 4'6". The boats could cover a distance of about 15 miles in a time of 3½ hours with favourable wind conditions. The boats could carry a maximum of between 2000 to 4000 lbs of fish. Each boat was operated by a three man crew. The sailing boats were unstable and difficult to maneuver. Steering required the coordinated efforts of repositioning the main sail while shifting up to 200 lbs of iron ballast located in the bottom of the boat. These factors all greatly limited potential fishing effort by limiting both the distance that the boats could travel and the time spent fishing. The number of fishing days was also limited by wind conditions. Boats could not be safely put to sea on either very windy or calm days. The ability to steer to the best fishing grounds was also greatly constrained.

Motorisation of the vessels greatly alleviated many of these problems. The early motorised day launches that first entered the fleet in the 1950’s typically ranged from 22' to 30' in overall length with beam lengths of between 7' 6" to 11' and draughts of approximately 3' to 3' 9". The frames were constructed of mahogany or white cedar with skinning of pitch pine and spruce. The keels were of pitch pine or greenheart. The engines were at the center of the boats protected by a cabin house of approximately 7' to 8' in length. The vessels were propelled by marine diesel engines ranging in power between 10HP to 36 Hp enabling the vessels to achieve maintained speeds of between 7 to 9 knots. With these vessels, fishermen could travel greater distances and were better able to reach the precise locations where they wished to fish. More room was also available for the storage of fish.

The basic design of modern dayboats is not greatly different than that of the first vessels of their kind. The size of the vessels and motor power are the only significant improvements in the efficiency of this type of vessel. The largest typical modern day boats are 41.6 ft overall length, 13.3 ft. beam length and a draught of 4.4 ft. The most powerful engine is 300 hp. The present fishing fleet includes a wide size range of fishing vessels. For the purposes of registration, vessels are now placed into certain size classes, based on overall hull length. The size classes are: class 1 = vessels < 6m; class 2 = vessels 6-12m; and class 3 = vessels > 12m length overall.

The second major development was the addition of an insulated box that served as an ice-hold on some vessels. The insulated ice-hold was introduced in the mid-1970’s and rapidly grew in popularity throughout the 1980’s. The original iceboats were simply day boats to which an ice hold had been secured to the aft deck, behind the wheelhouse. This basic design was kept with the only other modifications being an increase in the size of the hull to better accommodate the ice-hold. Ice holds varied greatly in size and by the end of the 1980’s ranged in capacity from 8 to 20 m^3 of ice and fish. The surfaces of the typical ice hold were coated with glass-reinforced plastic (GRP or fiberglass). During the 1980’s especially, the use of this material to coat the hulls of all types of fishing vessels in Barbados also became very popular. A synopsis of the types of hulls present in the modern registered Barbados fishing fleet is presented in table 1.

The final major development in the island's pelagic fishing fleet was the introduction of long-liners in the 1990's. The first few longliners were converted iceboats, but the cramped conditions caused by the presence of the bulky longline gear on the deck, quickly indicated the need for the introduction of purpose built vessels.

The last category of commercial fishing vessel that for completeness should be mentioned, are the small open dinghies locally referred to as "Moses". Dolphinfish is only very occasionally, captured by fishers operating from Moses. Figure 1 illustrates the comparative importance of each of these types of fishing vessel to the local dolphinfish fishery, where the vast majority of the local catch (82%) is landed by the iceboats. It is interesting to note that day boats and longliners each take 9% of the total catch.

Fishing methods

Dolphinfish are major predators of the flying fish (Hirundicthys affinis) and as such dolphinfish are most often found in close proximity to flying fish schools. It is not surprising therefore, that fishing for these two species occurs practically simultaneously. At sea the fisherman searches for the presence of flotsam and uses this as an indicator of a potentially productive fishing ground. Once a good ground is located, the fisherman turns off the boat's engine and allows the vessel to passively drift with the surface currents. If still deployed, the fisherman would then haul in his trolling lines.

Unless dolphinfish or other large pelagics are sighted immediately, the fisherman will generally first attempt to capture flying fish. For this he first deploys temporary fish attracting devices known as "screelers". A screeler is simply a bundle of sugar cane or coconut fronds that is attached to the boat by a length of rope. Most often a number of screelers (max of 6) are tied to the same line at roughly 100 m intervals. The fisherman may also then hang a basket of pieces of fish and offal (called "chum") over the side of the boat. As the boat rolls with the waves, the basket dips into the water causing the pieces of fish to spill out onto the sea. Once flying fish are spotted, the fisherman deploys a drifting gill net. He then pulls the screelers closer to the ship, positioning one behind the net. This action draws the flying fish into the vicinity of the net to facilitate their capture. At some point during the exercise the fisherman will deploy baited lurk lines to capture any large pelagics in the area (Harrison, 1988).

Two lurk lines are generally deployed, one attached to the bow and the other, to the stern of the vessel. If the dolphinfish and other large pelagics are not abundant, the fishermen may tie the lines to a sturdy part of the boat. A piece of string is tied to some point along the line and the other end attached to a part of the boat. This arrangement causes a small loop to be formed in the fishing line. When a fish is caught, the additional drag causes the fishing line to extend to its fullest thus breaking the string and signaling to the fishermen that a fish has been hooked. However, if dolphinfish or other large pelagics are abundant in the area, the fishermen may simply keep holding the line until a dolphinfish is hooked. When large pelagics come into the area, the drift nets are immediately hauled out of the water to avoid the risk of these large fish damaging them.

Flying fish are reportedly most abundant just after mid-day and just before sunset, while dolphinfish seem to accumulate overnight and are found mostly around dawn. (Harrison, 1988). It is very difficult to confirm the locations of the most productive fishing grounds. However most of the local fishing effort for these pelagic species is concentrated in the waters south west of Barbados.

Fish marketing and data collection systems

The following extract, taken from Parker (1999), describes the marketing and data collection systems for fish in Barbados.

> "By the middle of the 1950's four fish markets (also referred to as primary landing sites (FMP, 1997) were in existence in Barbados. The markets were located in the three largest towns, Cheapside and Bay Street (in Bridgetown), Oistins and Speightstown. The market buildings were all similar in their basic design. In addition nine fish landing sheds were located at some of the other more active fish landing areas namely, Consett Bay, Skeetes Bay, Tent Bay, Paynes Bay, Martins Bay, Half Moon Fort, Reads Bay, Fitts Village and Pile Bay. These sites became known as secondary landing sites. Finally, there were also a number of other areas around the island where, despite the absence of any permanent, physical infrastructure, fish were landed and sold. These sites are referred to as tertiary landing sites.
>
> Although the overall list of fish landing locations has remained more or less the same over the last fifty years, several infra-structural changes have occurred at several of the sites during this period. For example, the old market buildings at Oistins and Cheapside were replaced by the much larger and improved Oistins Fisheries Complex (1983) and Bridgetown Fisheries Complex (BFC) (1989), respectively. The secondary landing site at Reads Bay was upgraded to a primary site with the construction of the Weston fish market. The Bay Street market was closed shortly after the opening of the BFC.
>
> As a consequence of the marked infra-structural improvements that occurred at these landing sites, there was a commensurate shift in fish landing patterns around Barbados with most of the fishing fleet, notably the pelagic fleet preferring to operate out of the market sites. One exception seems to be the shift in popularity from the Speightstown market to the neighbouring tertiary site at Six Mens Bay.
>
> In addition to the physical infra-structural differences among the three categories of landing sites, there are significant differences in both the staffing and marketing operations at the sites. The first major difference is that there is no official management of landing and marketing operations at the tertiary landing sites. The responsibilities of managing fish markets were passed to the Markets Division immediately after the markets first began operations in the 1950's. These markets required more staff than were

needed at the sheds. Tolls were paid based on the quantity and types of fish landed at the market. For this reason, fish were placed into broad taxonomic groupings and weighed for the calculation of the tolls payable. The weights and types of fish landed were recorded in toll books. At the end of each day, the weights of each fish group were totalled and the number of boats that landed fish on that day was reported on standardised data summary sheets. The summarised data was then submitted to the Fisheries Division, while the toll books were traditionally retained at the fish markets. In addition to fish landings the prices of received at the market for each type of fish were recorded and periodically forwarded to the Fisheries Division.

The Fisheries Division retained the responsibilities of managing the fish sheds. Usually someone living in the vicinity of the shed was appointed as caretaker. Fishermen were not required to pay tolls for the use of the fish shed and landings statistics were not collected at fish sheds before the 1970s. From that time, summarised fish landing statistics were recorded on standard data summary sheets and periodically submitted to the Fisheries Division.

The summarised fish landing statistics were useful in assessing some of the economic aspects of the fishing industry (for example calculation of the industry's contribution to GDP etc.). However, the only measures of fishing effort recorded were, the numbers of boats landing fish (note that neither the number of unsuccessful fishing trips were recorded, nor could landings made at the site when the caretaker was absent), the number of days when fish were landed (note that this does not indicate the number of unsuccessful fishing days) and finally, the number of days spent fishing on multi-day fishing trips. These data were also rendered less useful by the fact that the types of fishing vessels landing the fish were not originally recorded.

The format of the data summary sheet was changed in 1981 in an effort to improve the accuracy and usefulness of the data collected for fisheries management purposes. Improvements included changing the group headings to better define the fish species to be included and separating the boats into the categories of launch and dinghy (moses).

The quality of fish landings statistics was further greatly improved through the CFRAMP programme, which started in Barbados in 1993. A key feature of the improved data collection programme was the addition of Data Collectors to the staff of the Fisheries Division. The main duties of the data collectors were to:

Obtain estimates of the quantities and types of fish landed at tertiary sites through regular, scheduled visits to the sites.

To measure samples of certain key fish species to gather basic morphometric data on the species and to gather more detailed information on fishing operations (e.g. types of gear used to catch the fish, length of fishing trip, approximate location of fishing activities, etc.)

> In addition, data were entered into a computer programme developed specifically to manage fisheries data, known as the Trip Interview Programme (TIP) (Coughtry et al., 1996). Toll book records, which continued to be the main sources of fish landing data collected from the markets were entered directly into TIP. A companion programme known as the Licensing and Registration System (LRS) was also introduced into which technical data on fishing vessels (type, length etc.) were entered. By integration of the two databases (from TIP and LRS), a variety of useful information relevant to fisheries management could be obtained. One simple example was that the landings of certain important fish species such as flyingfish, could be broken down by vessel type."

This latter facility is especially important in controlling for the significant differences in fishing effort (numbers of days fished, area covered during fishing etc.) that exist between the types of fishing vessels in the Barbados fleet. Despite this however, it is well recognized that fishing effort needs to measured more accurately. The only feasible method for doing this is through the use of fishing logbooks. A draft logbook format has already been produced and will hopefully be introduced to local fishers in the near future.

In Barbados, current total estimated catches of dolphinfish for the whole island are generally calculated by multiplying the total landings of dolphinfish recorded at the primary and secondary landing sites by a factor of 1.2. However, as it is difficult to devise appropriate raising factors for past years, total landings recorded at the primary and secondary landing sites are used for historical comparisons in this document.

Trends in landings and fishing activities

Dolphinfish currently account for the second largest portion of fish landings (26 %) in Barbados (Figure 2). The mean annual catch of dolphinfish recorded at the major landing sites in Barbados over the last eleven years is 649 metric tones.

The historical reports of Barbadian fisheries all strongly illustrate the striking seasonal pattern of the dolphinfish and other pelagics captured locally (Brown, 1942, Hall, 1956, Bair, 1962, Oxenford and Hunte, 1985, etc.). Figure 3 illustrates the similarity between the seasonal pattern of dolphinfish landings observed over the last eleven years (represented by monthly means) with that reported for 1962 by Bair (1962). The graphs clearly show a gradual increase in dolphinfish catches over the first four months of the calendar year, reaching a peak in April. This is followed by a sharper decline over the following four months. The catches slowly start to increase again in December. Figure 4 however, illustrates that the annual peak is not as well defined each year and even when clearly discernible, may occur at any month between February and May of the year in question.

It is noteworthy that the great majority of the pelagic fleet does not operate during the period between July and September and that the maximum number of pelagic vessels are not actively fishing until the early part of the year. It is therefore difficult to tease out the effect of this variation in fishing effort from bona fide differences in availability of the resource at fishing grounds. Figure 5 demonstrates the existence of generally little fluctuation in annual dolphinfish catches over the eleven year period with the exception of the very noticeable peak catch of 1992.

Table 1. Hull types of Barbadian fishing vessels in 1999. GRP = glass reinforced plastic (fiberglass).

Hull type	Iceboat	Launch	Longliner	Moses	Total
ALUMINUM	0	0	0	1	1
GRP	44	64	19	339	466
GRP/WOOD	4	15	1	26	46
PLASTIC	0	0	0	1	1
STEEL	0	0	5	0	5
WOOD	103	203	6	48	360
Total	151	282	31	415	879

Figure 1. Distribution of recorded dolphin catch among Barbadian fishing vessels in 1999

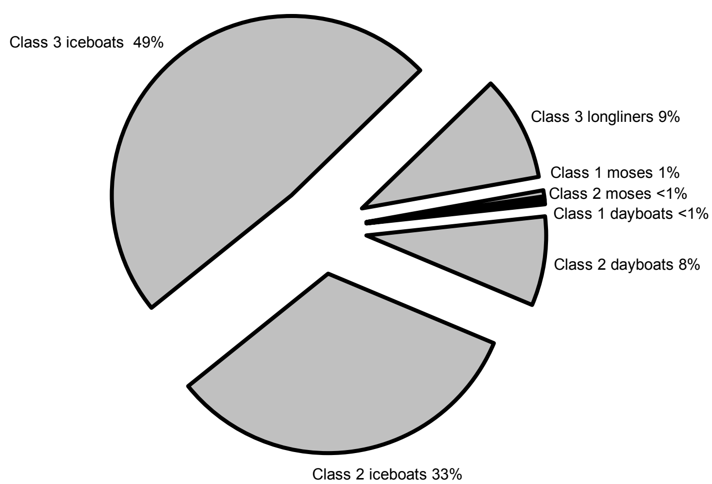


FIGURE 2. Mean annual catch composition of local vessels (% of total) in Barbados (1989-1999).

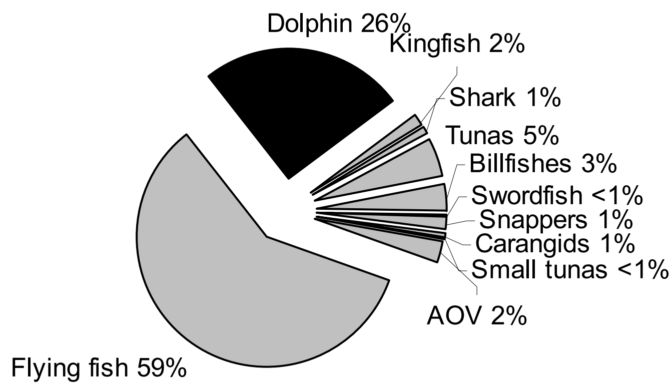


FIGURE 3. Pattern of mean monthly catches (mt) of dolphinfish recorded at major landing sites in Barbados over the period 1989-1999 (solid line) and estimated total catches in 1962 (dashed line).

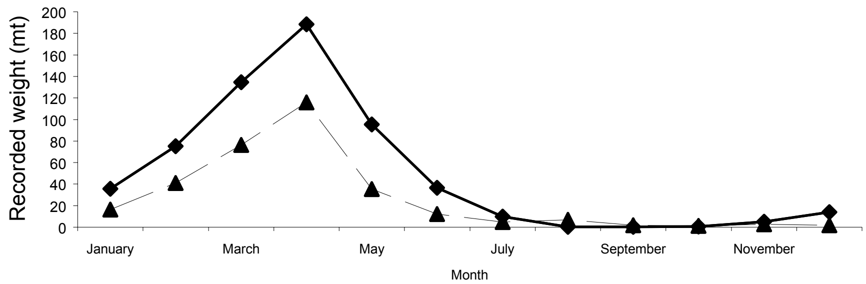


Figure 4. Monthly landings of dolphins (mt) recorded at primary and secondary sites in Barbados (1989-1999)

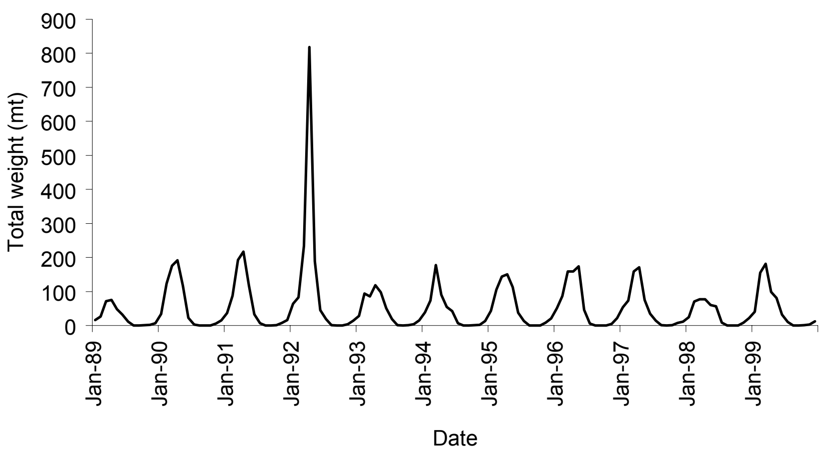
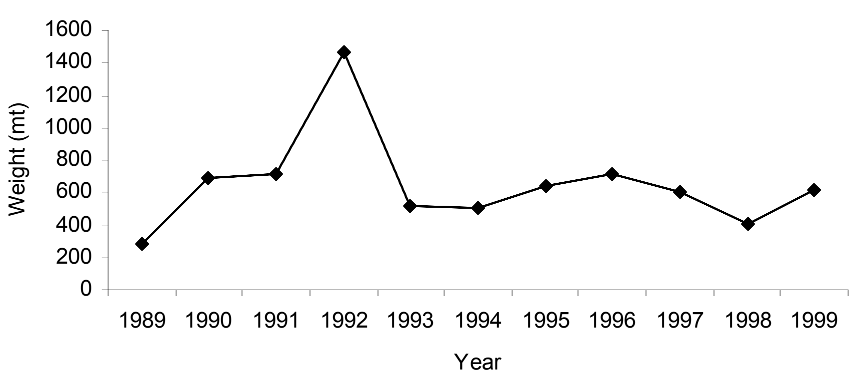


FIGURE 5. Total annual catches (mt) of dolphinfish recorded at major landing sites in Barbados (1989-1999)



List of References

Bair R.A., 1962. The Barbados fishing industry: The development and economic importance of a fishing industry in the tropics. M.A. thesis, Dept. of Geography, McGill Univ., Montreal. 58 pp.

Brown H. H., 1942. The sea fisheries of Barbados. *Bull. Develop. Welf. B.W. I.* Bull. No.1. 42 pp.

Campana, S.E., 1996. Assessment, training and recommendations pertaining to the operational capabilities of the Institute of Marine Affairs Ageing Laboratory in Trinidad. Consultancy Report.

CFRAMP, 1996. CFRAMP Tropical Fish Stock Assessment Training Workshop, organised by the CARICOM Fisheries Resources Assessment and Management Program (CFRAMP) in collaboration with the Food and Agricultural Organisation (FAO). January 01 –31 1996.

Choat, J. H. and L. M. Axe, 1996. Growth and longevity in acanthurid fishes; an analysis of otolith increments. *Marine Ecology Progressive Series*, 134, 15 – 26.

Claro, R. and Y.S. Reshetnikov, 1981. Ecologia y ciclo de vida de la biajaiba, Lutjanus synagris (Linnaeus), en la plataforma cubana. I. Formacion marcas de crecimiento en sus estructuras. Academia de Ciencas de Cuba. Informe Cientifico-Tecnico 174, 28p

Craig, P.C., 1999. The von Bertalanffy growth curve: when a good fit is not good enough. *Naga, the ICLARM Quarterly*, 22 (4).

Franks, J. S., J. L. Shea, N. J. Brown-Peterson, M. S. Griggs and K. M. Larsen, in press. Attempts to enhance the visibility and contrast of presumed growth marks on sagittal otoliths from Wahoo, *Acanthocybium solandri*, from the Northern Gulf of Mexico and Bimini, Bahamas. Presented at the 52nd Gulf and Caribbean Fisheries Institute.

Gayanilo Jr. F. C., and D. Pauly, 1997. FAO-ICLARM Stock Assessment Tools, FAO.

Gold, S. M., 1990. User's guide for the micro computer based data entry portion of TIP the Trip Interview Program: Data entry system version 3.0. NMFS. SFC, NOAA, Florida, USA.

Hall D.N.F., 1956. Recent developments in the Barbados flying fishery and contributions to the biology of the flying fish – *Hirundicthys affinis* (Gunther 1866). Colonial Office Fishery Publication. No. *7*, 41 p.

Harrison L.D.M., 1988. Barbados iceboat report. In: Final report of the technical co-operation ATN/SF-2474-BA institutional strengthening of Fisheries Division of Ministry of Agriculture, Food and Fisheries to the Government of Barbados. Crown Agents for Overseas Governments and Administrations, England.

Harvey, G., 1986. Coastal pelagic fisheries resources in the Caribbean Part IIA. UWI, Zoology Department Research Report #7.

Harvey, G., 1984. Artisanal fisheries for herring in Jamaica in alternative artisanal fishery resources session. Comision Nacional de Pesca, San Jose, Costa Rica.

Heileman, S., 1987. A preliminary survey of clupeoid fishes of Trinidad with notes on *Opistonema oglinum, Sardinella aurita* and *Harengula jaguana*. IMA, Chaguaramas, Trinidad and Tobago. 29p.

Hunte, W., 1987. Summary of the available database on oceanic pelagic fisheries in the Lesser Antilles. pp 125-176 In Mahon, R. (ed.) 1987. Report and Proceedings of the

Expert Consultation on Shared Fishery Resources of the Lesser Antilles Region. Mayaguez, Puerto Rico, 8-12 September 1986. FAO Fish Rep., 383, 278 p.

Huntsman, G. R., C. S. Manooch, and C. B. Grimes, 1983. Yield per recruit models of some reef fishes of the U.S. South Atlantic Bight. *Fishery Bulletin*, 81, (4), 17p.

IMA and CFRAMP, 1994. Provision of age and growth data – Working paper presented at the Large Pelagics, Reef and Slope Fishes Subproject Specification Workshop. Document No. 34.

IMA and CFRAMP, 1994. Provision of age and growth data – Working paper presented at the Large Pelagics, Reef and Slope Fishes Subproject Specification Workshop. Document No. 34.

Johnson, A. G., L. A. Collins, J. Dahl, and M. Scott Baker Jr., 1995. Age and growth and mortality of lane snapper from the northern Gulf of Mexico. *Proc. Annu. Southeast. Assoc. Fish and Wildl. Agencies*, 49, 178-186.

Jones, C.M., 1992. Development and application of the otolith increment technique. In: Otolith Microstructure Examination and Analysis edited by D.K. Stevenson and S.E. Campana. *Canadian Special Publication of Fisheries and Aquatic Sciences*, 117, 1-11.

Julien-Flüs, M., 1988. A study of growth parameters and mortality rates of *Scomberomorus brasiliensis* from coastal waters of Trinidad, West Indies. In Contributions to Tropical Fisheries Biology edited by S. Venema, J. Möller-Christensen and D. Pauly. FAO Fisheries Rep. No. 389. FAO Rome.

Kishore, R., 2000. Age and growth determination of the lane snapper, *Lutjanus synagris* from Belize and Jamaica. Draft Report. Document prepared for the CARICOM Fisheries Resources Assessment and Management Program (CFRAMP).

Kishore, R. and L. Martin, 1998. Age and growth studies of the Spanish mackerel, *Scomberomorus brasiliensis* (Family: Scombridae) in coastal waters of Trinidad. Presented at the 2nd International Symposium on Fish Otolith Research and Application. Bergen, Norway, 20 – 25 June 1998.

Mahon, R., 1996. Fisheries research for tunas and tuna-like species in the Western Central Atlantic: implications of the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Stocks and Highly Migratory Fish Stocks. FAO Fisheries Technical Paper. No. 357. Rome. 62p.

Mahon, R., 1999. Dolphinfish fisheries in the Caribbean region.. *Sci. Mar.*, 63 (3-4), 411-420.

Mahon, R., F. Murphy, P. A. Murray, J. Rennie and S. Willoughby, 1990. Temporal variability of catch and effort in pelagic fisheries in Barbados, Grenada, St. Lucia, and St. Vincent: with particular reference to the problem of low catches in 1989. FI:TCP/RLA/8963 Field Document 2. FAO. 74p.

Manickchand-Dass, S., 1987. Reproduction, age and growth of the lane snapper, *Lutjanus synagris* (Linnaeus), in Trinidad, West Indies. *Bull. Mar. Sci.* 40 (1), 22-28.

Manooch, C. S. and D. L. Mason, 1984. Age and growth and mortality of lane snapper from southern Florida. *Northeast Gulf Sci.* 7, 109-115.

Matthes, H., 1984. Saint Vincent and the Grenadines formulation of a fisheries development programme. FAO Field Document No. 1. FAO, Rome. 190p.

Mohammed, E., 1997. Reports on the drifting fishery of Tobago. Internal Report.

Murray, P. A., 1989. A comparative study of methods for determining mean length-at-age and von Bertalanffy growth parameters for two fish species. M. Phil. Thesis, University of the West Indies, Cave Hill, Barbados, 222p.

Murray, P. A. and S. B. Barnwell, 1994. Procedural manual for the use of the Trip Interview Program with fisheries catch and effort data in the Caribbean Community. FD, OECS report.

Murray, P. A. and W. B. Joseph, 1996. Trends in the exploitation of the wahoo, *Acanthocybium solandri*, by the St. Lucian pelagic fishery. *Proc. Gulf Carib. Fish. Inst.*. 44, 737-746.

Murray, P. A. and W. B. Sarvay, 1987. Use of ELEFAN programs in the estimation of growth parameters of the wahoo, *Acanthocybium solandri*, caught off St. Lucia, West Indies. *Fishbyte*. 5 (1), 14-15.

Murray, P. A., S. B. Barnwell, and A. Clemetson, 1995. A manual of CARICOM procedures for entry and reporting of fisheries data with the Trip Interview Program. Version 3.3. CARICOM Fisheries Management Unit, Belize City.

Murray, P. A., H. A. Oxenford, and B. E. Luckhurst, in prep. A review of the biology of wahoo (*Acanthocybium solandri*) in the western central Atlantic.

Nomura H. and M. S. de Sousa Rodrigues, 1967. Dados biologicos sobre a serra, *Scomberomorus maculatus* (= *Scomberomorus brasiliensis*) (Mitchill), das aguas cearenses. *Archos Est. mar. Univ. Cearca*, 7, 29-39.

Oxenford, H. A., 1999. Biology of the dolphinfish (*Coryphaena hippurus*) in the western central Atlantic: a review. *Sci. Mar.*, 63 (3-4), 277-301.

Oxenford H. A. and W. Hunte, 1985. Long term trends in the abundance of the dolphin, *Coryphaena hippurus*, near Barbados. *Proc. Gulf Carib. Fish. Inst. 38.*

Pandohee, E., 1996. Reports on the drifting fishery of Tobago. Internal Report.

Parker C., 1999. Developments in the flyingfish fishery of Barbados. In. Report of the first meeting of the WECAFC ad hoc flyingfish working group of the Eastern Caribbean. Bridgetown, Barbados, 22-24 September 1999. FAO Fisheries Report No. 613. SLAC/R613.

Pedroso, B. L. and E. Pozo, 1991. Edad y crecimiento de la baijaiba (*Lutjanus synagris* Linnaeus, 1758) en el Golfo de Guacanayabo, Cuba. FAO Fish. Rep. No. 431.

Potts, A.C., 2000. Catch and effort landing data Tobago House of Assembly 1988-1999. Fisheries Internal Report.

Pozo, E., B. Pedroso and M. H. Obregón, 1991. Edada y crecimiento de la baijaiba (*Lutjanus synagris* Linnaeus, 1758) en el Golfo de Guacanayabo, Cuba. FAO Fish. Rep. No. 431.

Rodriguez Pino, Z., 1962. Estudos estadisticos y biologicos sobre la biajaiba (*Lutjanus synagris*). Centro de Investigaciones Pesqueras. Nota sobre Investigaciones (4), 96 pp.

Ryan, R., 1999. St. Vincent and the Grenadines fisheries status report 1997. Fisheries Division Internal Report. 72p.

Sadovy, Y. and M. Figuerola, 1989. The status of the red hind fishery in Puerto Rico and St. Thomas as determined by yield-per-recruit analysis. *Proc. Gulf Carib. Fish. Inst*.

Sahney, A.K., 1983. Sample survey of the fishing industry in Jamaica – 1981.

Samlalsingh, S., 1996. Reports on drifting fishery of Tobago. Internal Report.

Sluczanowski, P., 1985. The Beverton and Holt yield per recruit model using LOTUS 1-2-3. Fisheries Research Paper #13. 30p.

Sparre, P. and S. C. Venema, 1992. Introduction to Tropical Fish Stock Assessment. FAO Fisheries Technical Paper 306/1 rev.1. 376p.

SPSS, 1998. SPSS Base 8.0 for Windows. User's guide SPSS Inc., Chicago.

Sturm, M.G., 1978. Aspects of the biology of *Scomberomorus maculatus* (= *Scomberomorus brasiliensis*) (Mitchill) in Trinidad. *J. Fish Biol*. 13, 155-172.

Willoughby S. and D. Leslie, 2000. Fishing gear of Barbados. Fisheries Division Report. *FDR-002-2000*. Fisheries Division, Ministry of Agriculture and Rural Development, Barbados.

Ximenes M. O. C., 1981. Idade e crecimento da serra. *Scomberomorus brasiliensis*, no estado do Cercá (Brasil). *Arq. Ciên. Mar*, 21, (1/2), 47-54.