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Report of the Third Meeting of the
Ad hoc Working Group on Methods
27-30 November, Grenada

Report of Fourth Annual Scientific Meeting -
Kingstown, St. Vincent and the Grenadines
10-20 June 2008

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Foreword

CRFM's Fourth Annual Scientific Meeting took place during 10-20 June, 2008. During this Meeting, CRFM Resource Working Groups examined data from nine fisheries: the crevalle jack (*Caranx hippos*) fishery of Trinidad and Tobago; the spiny lobster (*Panulirus argus*) fisheries of The Bahamas and Jamaica; the queen conch (*Strombus gigas*) fishery of St. Lucia; the reef and slope fisheries of the Turks and Caicos Islands and St. Kitts and Nevis; the whitemouth croaker (*Micropogonias furnieri*) fishery of Trinidad and Tobago; and the Atlantic Seabob (*Xiphopenaeus kroyeri*) fisheries of Guyana and Suriname. A plan of action was developed for strengthening the information base necessary to inform the establishment of management and conservation measures for small coastal pelagic fisheries. In addition, the Large Pelagic Working Group conducted a review of the region's fisheries in order to evaluate assessment priorities and to develop a workplan for addressing required assessments and improving collaboration with ICCAT. The Meeting reviewed and adopted the Report of the Third Meeting of the CRFM Ad Hoc Working Group on Methods. A proposal to establish a Working Group on Data, Methods and Training was considered and endorsed by the Meeting.

The Report of the Fourth Annual Scientific Meeting is published in two Volumes: Volume 1 contains the proceedings of the plenary sessions and the full reports of the CRFM Resource Working Groups for 2008. National reports, submitted for consideration by the Meeting, are published as Supplement 1 to Volume 1, while the Report of the Third Meeting of the Ad Hoc Working Group on Methods is published as Supplement 2 to Volume 1. Volume 2 contains the general reports of each Working Group and the fishery management advisory summaries for completed fishery assessments. These fishery management advisory summaries are the same as the first 7 sections (sections 1 to 1.7) of each of the fishery assessment reports that are provided in full (sections 1 to 1.8) in Volume 1.

Volume 1 is intended to serve as the primary reference for fishery assessment scientists, while Volume 2 is intended to serve as the main reference for managers and stakeholders. Sincere thanks to Mr. Greg Franklin for providing the photographs which appear on the covers of these two volumes.

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1. Opening of the Meeting

The Meeting was opened by Mr. Johnson St. Louis, Acting Chief Fisheries Officer, Fisheries Division, Grenada.

2. Election of Meeting Chair and rapporteuring arrangements

Mr. Crafton Isaac was elected Chairperson of the Meeting. Mr. Paul Phillips was elected Deputy Chairperson. CRFM Secretariat staff served as the rapporteurs.

3. Introduction of participants

A list of the participants is provided in Appendix 1.

4. Adoption of Meeting Agenda

The Meeting agenda was adopted without modification. The adopted agenda is given in Appendix 2.

5. Method tests - Continuation of method tests using real data, and presentations of work completed to date.

Several activities were undertaken in respect of testing analytical approaches/methodologies, with some methods still in the process of being tested. The reports of the progress of each of these activities are given in Appendix 3.

6. Meeting of the Working Group on Data

The Working Group on Data met on 28 November 2007, to address agenda items 6.1-6.3.

6.1 Implementation of recommendations of Second Meeting

(i) Computerization of historical data and obtaining additional data from countries – The Secretariat informed the meeting that attempts to obtain additional completed data availability questionnaires from countries had not yielded results. Additionally, a separate template for documenting the existence of historical data was not considered necessary. Recognizing the value of long time series, especially of total catches for tracking the history of the fishery, the Working Group recommended that countries document those types of data that have been collected in the past and also those data that are being collected at present. Further documentation of data, as well as provision of historical data would be given attention on a case by case basis, and determined by priorities identified at the annual scientific meetings.

(ii) Collaboration with Fishbase and Cephbase – The Working Group reinforced the recommendation that fisheries scientists within CRFM countries should ensure that their scientific publications are shared with these global databases. The Working Group acknowledged that these databases were not exhaustive in terms of all available data and knowledge of the resources, and noted that the FISHBASE format did not always provide the required data in a usable format. As such, the usefulness of regional summaries was not considered further by the Working Group during the meeting.

(iii) Provision of training – The CRFM Secretariat informed the Working Group that a 1-day training session had been organized during the 2007 Annual CRFM Scientific Meeting. Given the length and extensive demands of the annual scientific meetings, the Working Group considered and agreed that it was desirable to have training conducted separately from the scientific meetings. There was some discussion about the development of training CDs/DVDs, which would ease the burden of having to train new staff. The Working Group appreciated that formal training with single-class sessions would not provide the perfect solution, because recipients' skills levels could vary markedly. The Working Group concluded that several options for training should continue to be considered, and should probably consist of both formal and 'on the job' training opportunities.

6.2 Options and recommendations for improvements in national data collection programmes

The method of 'unequal probability sampling' was introduced to participants via an oral presentation. A summary of the sampling method is provided in Appendix 3, VI (i).

There was some debate about the reliability of the method in instances of small probabilities. Despite this potential problem, it was agreed to conduct some simulations to help participants appreciate the full capabilities of the method, as well as possible pitfalls. The results are presented in Appendix 3, VI (ii).

6.3 Proposal to resume operations of regional fish age and growth laboratory housed at IMA

Participants listened to an oral presentation of a proposal to re-establish a regional fish and age growth laboratory, similar to the one established under the auspices of CFRAMP. A summary of the present version of the proposal is given in Appendix 4.

The importance of age and growth data was recognized by the Meeting and resumption of this type of work was considered necessary. The Meeting acknowledged that national data collection programmes would have to resume some level of biological sampling to ensure the success of the proposed age and growth research. Participants did not receive a hard copy of the full proposal for review during the Meeting, and hence it was agreed to circulate the first draft by email (version given in Appendix 4). The Meeting recommended that the proposal be forwarded to the Scientific Meeting for review and adoption.

7. Recommendations/guidelines for application of approved methods to CRFM fisheries situations - based on agreed method evaluation criteria, develop recommendations/guidelines of the various methods tested

During the first meeting of the Working Group, methods were evaluated using specific agreed evaluation criteria, and the evaluation results were tabulated. During its final meeting, the Working Group prepared a second table to summarize the evaluation results of methods tested during the second and third meetings. This table is provided as Appendix 5.

8. Review of the progress of the Ad Hoc Working Group on Methods since its inception - Review of Working Group's Terms of Reference and issues addressed

Review current management advice needs and constraints within CRFM countries (Terms of Reference 1).

To facilitate this activity, the Secretariat had prepared a questionnaire for completion by fishery managers in CRFM countries. The questionnaire was designed to provide information on management priorities and constraints. The Working Group endorsed the questionnaire during its first meeting. Thirteen countries had submitted completed questionnaires, and these data were reviewed by the Working Group during its first and second meetings. Additionally, the questionnaires were compiled by the Secretariat and prepared as a CRFM publication (CRFM, 2007a)

Develop recommendations to improve communications between scientists and managers (Terms of Reference 2).

During the first meeting of the Working Group a smaller working group was established to review options for improving communications among scientists, stakeholders and managers. Guidelines were proposed by the smaller Working Group, which were accepted during the second meeting of the Working Group. The Working Group recommended that countries follow the proposed guidelines, and advise on their pertinence and usefulness.

Conduct a comprehensive review of resource and fisheries assessment methodology, select those tools considered most useful for providing immediate contributions to the fisheries management process within the CRFM region, and then test selected software tools using simulated and real data (Terms of Reference 3, 4 & 6).

Several analytical approaches/ methodologies were identified, some of which were suitable for fisheries data situations in CRFM countries. The Working Group attempted to test these analytical approaches/methodologies during its three meetings and also during the inter-sessional periods. For some tests, additional data had to be collected. The Working Group was able to explore several approaches/ methodologies for which data were readily available and within the time constraints of the life span of the Working Group.

Develop and apply criteria for evaluating the performance and suitability of the tools examined (Terms of Reference 5).

During the first meeting of the Working Group, a set of evaluation criteria were developed. These criteria have been applied for reporting on each analytical approach/methodology tested. The agreed evaluation criteria were:

1. Data requirements/ availability/ possibilities
2. Type of management advice (ability to provide information based on stated objectives)
3. Expected management actions (practicalities)
4. Level of skills required
5. Attributes of the fishery (multispecies, multigear)
6. Cost, risks/ benefits of applying a particular method (the issue of trade-offs)

Develop recommendations for applying assessment tools to specific fisheries management situations within CRFM countries Terms of Reference 7).

The results of tests performed have been tabulated for ease of presentation. Table 2 of the report of the first meeting of the Working Group provides the recommendations for applying assessment tools reviewed during that meeting. The table in Appendix 5 provides the recommendations for applying assessment tools reviewed during the second and present meetings of the Working Group.

Consider and pursue additional tasks pertaining to development and application of appropriate assessment methods, as appropriate (Terms of Reference 8).
The Working Group made recommendation for collection of additional data to facilitate testing of selected analytical approaches/ methodologies. These additional data were not collected during the life span of the Working Group, but at least two countries plan to undertake the necessary additional data collection in 2008.

Develop practical recommendations to improve data collection for successful implementation of approved assessment methods (Terms of Reference 9).
These issues were addressed during the meetings of a smaller working group established to review data issues, and recommendations for data improvements were documented in the reports of this smaller working group. Additionally, in 2006, the CRFM Secretariat, in collaboration with selected fisheries staff, prepared a data availability questionnaire to obtain detailed information from countries in respect of their fisheries data and information systems, including the availability and quality of the data collected. These questionnaires were reviewed by the smaller working group, and have since been compiled and summarized into a CRFM publication (CRFM 2007b)

Document findings in meeting reports, and present findings to the Annual CRFM Scientific Meetings (Terms of Reference 10).
The findings of the Working Group are documented in reports of its first, second and third meetings. To date, the first and second meeting reports have been reviewed and adopted formally during the 2006 and 2007 Annual CRFM Scientific Meetings. The present report, which is the report of the third meeting, will be presented for formal review and adoption during the Annual CRFM Scientific Meeting in 2008.

9. Recommendations for the way forward - Consideration of the need to establish a permanent working group to deal with data and methodological issues, and proposed terms of reference

The meeting recognized the need to keep under review the methodologies adopted and currently being applied, as well as the need to explore new methodologies being introduced. In addition, the meeting noted the advantage of being able to examine data issues and conduct data preparatory tasks during the inter-sessional period. A Permanent Working Group could also provide a forum for continued training, as required, both in the form of formal and 'hands-on' training opportunities. There was also agreement on the importance of networking with other agencies, institutions, projects, etc., which were engaged in addressing similar and related issues.

The Meeting therefore endorsed the idea of establishing a Permanent Working Group on Data on Methods, which would be able to handle the following main areas of work: data preparation for assessments; review of current methods; testing of new methods; training; collaboration with other agencies and institutions with similar and related interests. The need for an annual on-site meeting of the Permanent Working Group was discussed, but there was no consensus on this point.

10. Any other business

The Working Group viewed a film providing information about an ongoing FAO project to examine the extent of bycatch in trawl fisheries and ways of reducing bycatches. During its first phase, this project had involved a number of southern Caribbean, and countries of Latin America. The Working Group was advised of the importance of such an initiative and of plans to have a second phase of activities. The final meeting to review the results of phase 1 of the FAO project was scheduled for June-July 2008. It was noted that consideration should be given to invite all those countries with trawl fisheries to the final meeting of the project's phase 1, as this would help to encourage the participation of more countries in activities proposed for phase 2.

11. Review and adoption of third and final report of the Ad Hoc Working Group

It was agreed to adopt the report by mail, and to submit all comments and proposed modifications no later than 14 December 2007, after which time the text of the report would be considered final.

12. Adjournment

The meeting was adjourned at 1230h on 30 November 2007.

13. References

CRFM (2007a). A questionnaire study providing an overview of fisheries management priorities and the existing supporting technical framework with 13 CRFM countries. *CRFM Research Paper Collection,* Vol. **3**, No. 2. Unpubl. Ms.

CRFM (2007b). A questionnaire study of the availability of data within eight CRFM Member Countries. *CRFM Research Paper Collection,* Vol. **3**, No. 3. Unpubl. Ms.

Hoenig, J.M. and Gedamke, T. (2007). A Simple Method for Estimating Survival Rate from Catch Rates from Multiple Years. Transactions of the American Fisheries Society 136:1245-1251.

Appendices

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Appendix 2 – Meeting Agenda

1. Opening of Meeting.
2. Election of Meeting Chair and rapporteuring arrangements.
3. Introduction of Participants.
4. Adoption of Meeting Agenda.
5. Method tests.
   - Continuation of method tests using real data, and presentations of work completed to date.
6. Meeting of the Working Group on Data.
   - 6.1 Implementation of recommendations of Second Meeting.
   - 6.2 Options and recommendations for improvements in national data collection programmes.
   - 6.3 Proposal to resume operations of regional fish age and growth laboratory housed at IMA.
7. Recommendations/guidelines for application of approved methods to CRFM fisheries situations.
   - Based on agreed method evaluation criteria, develop recommendations/guidelines for application of the various methods tested.
8. Review of the progress of the Ad Hoc Working Group on Methods since its inception
   - Review of Working Group's Terms of Reference and issues addressed.
9. Recommendations for the way forward.
   - Consideration of the need to establish a permanent working group to deal with data and methodological issues, and proposed terms of reference.
10. Any other business.
11. Review and adoption of third and final report of the Ad Hoc Working Group.
12. Adjournment.

Appendix 3 – Reports of Activities undertaken in respect of testing various analytical approaches/ methodologies

I. ERAEF analysis of the lobster fishery of St. Vincent and the Grenadines (Update)

This method test was still in progress at the time of the Meeting. The update provided by CRFM Secretariat staff highlighted the various stages of the ERAEF analysis. The first stage of the analysis involved completion of the following tasks: documentation of details of the characteristics of the fishery; identification of the units of importance with regard to the main ecosystem components, i.e. Target species, Bycatch/Byproduct species, Threatened, Endangered and Protected species, Habitat and Community; documentation of the core objectives and the operational objectives for the ecosystem components and their sub-components (e.g. population size and geographic range are two of the sub-components for the 'Species' component) respectively. We then identified and listed all activities (fishing and external activities) that occur and pose a hazard/risk to the species/habitat/community units of importance. These data were used to facilitate the next stage of analysis ('Level 1') which provided a qualitative screening of the likelihood of any unit-activity combination impacting sub-components and components to the extent that the relevant management objectives would not be fulfilled. Level 2 stage of analysis was reviewed briefly to examine the types of information required, but this stage of analysis would have to be completed inter-sessionally for the spiny lobster test data.

During the testing stage, the following challenges were noted.

(i) Operational objectives were not well defined for fishery analyzed.
(ii) The test has been limited by the level of data and information to guide identification of the units of analysis (species, habitats, communities); a literature review is being used to fill the data gaps.
(iii) The analyses are effected through a scoring process that is subjective. Stakeholder inputs, as well as access to information from independent research studies could help to diminish the level of subjectivity.
(iv) For this data-poor fishery, stakeholder input and data from ad hoc studies comprise a large component of the input.

Despite the challenges and extensive information required to complete the scoping stage, the ERAEF method offers the following opportunities.

(i) It is hierarchical, moving from qualitative/semi-quantitative to quantitative evaluations.
(ii) It allows screening and prioritizing.
(iii) It is precautionary in the absence of data.
(iv) Its use by countries will allow them to begin to address national and international obligations in accordance with regulations pertaining to environmental protection, protection of biodiversity, ecosystem-based management of fisheries, etc.
(v) It allows demonstration of 'no harm' caused by fisheries.
(vi) It has the potential to improve our understanding of the overall ecosystem and its functioning.
(vii) It allows the user to identify the 'key' issues for further consideration (if there is sufficient confidence in the data inputs), and this can save time and money, particularly when the fishery may consist of several target species, bycatch species, etc. In consequence, management objectives can also be refined.

(viii) It promotes the active involvement and support of stakeholders in the fisheries management process.

(ix) Management measures can be tailored to address more closely those species/habitat/community attributes considered most susceptible to identified hazards.

II. Social and Economic Framework

The social and economic framework for fisheries presented at the Second Methods Meeting by Pierre Failler was reviewed by a small group in order to create a plan of action (Figure 1). The group discussed the importance of capturing all the steps and pathways from production, to processing, market supply means and final markets within the fishery. A preliminary output of the group was the identification of some data which will need to be collected in order to complete the framework (Table 1); however it must be noted that this is not an exhaustive data list. These ideas were then presented to the Meeting for general discussion.

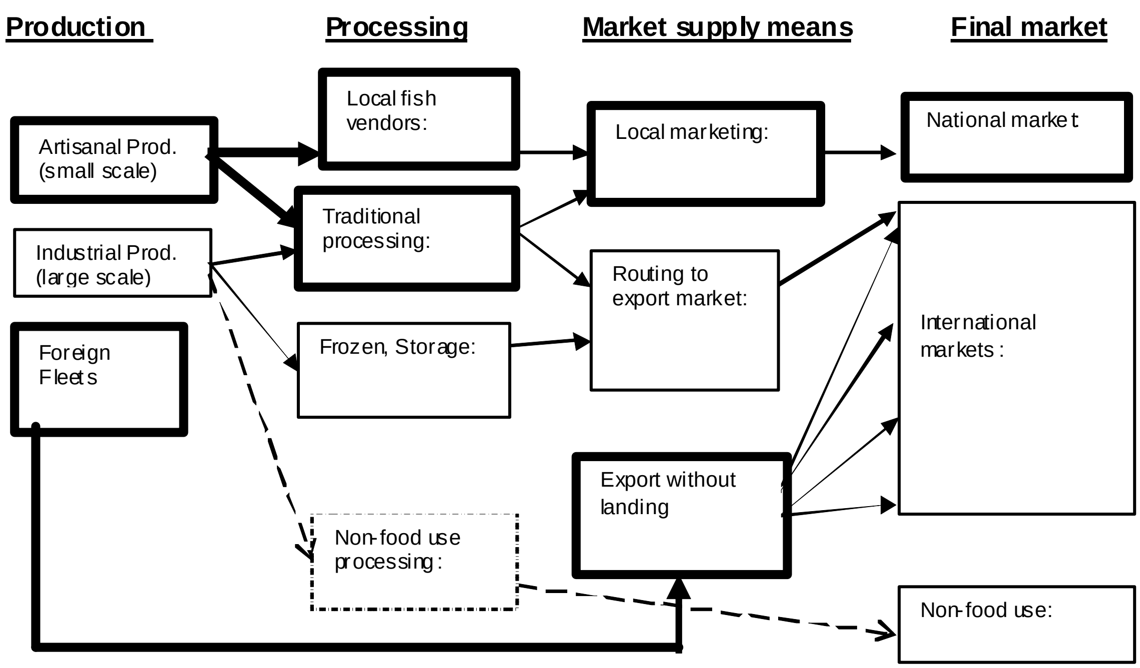

Figure 1: Production, processing and distribution information to be collected for each fishery by weight and value.

Table 1: Types of data that will need to be collected for the social and economic framework study.

Data to be Collected for Fleet Descriptions	Investment Costs Data	Revenue and Running Costs
Vessel types (age, engine size, length, construction material)	Vessel price	Average weight of fish by species caught per trip by gear
Gears used and fishing areas	Gear price	Average price per pound by species
Crew sizes	Engine price	Costs of distributing catch by weight/value to the markets
Duration of fishing trips by gear	Fishery Licence fee	Fuel costs per trip
Number of fishing trips per week	Other equipment (electronic, safety, specialized)	Other running costs (oil, food, bait, ice)

The Meeting recognized that the framework identified the key elements comprising the social and economic aspects of the fishing industry. In terms of using economic data to control fishing effort, it was noted that taxes on fishing vessels, gears and equipment could be used. In relation to this, the issue of subsidies was raised and it was suggested that this was one of the driving forces behind over fishing. It was therefore recommended that indicators and reference points were necessary to determine the linkages between factors such as subsidies and fishing effort. The detailed description of markets, processors, and the identification of other agencies which may have this data were highlighted as critical steps in the process of completing this framework.

The Meeting noted the importance of linking management objectives and policies in terms of the frame work. The importance of ensuring that the social and economic data collected were comparable among countries was highlighted. The point was made that knowing the social and economic value of a fishery is also extremely important with regards to making management decisions.

The Meeting agreed that the development of a methodology to collect these types of data based on this framework was important and the CRFM Secretariat proposed to commence a social and economic study to test the ideas discussed.

III- Catch-Only Model

(i) Introduction

Vasconcellos and Cochrane (2005) proposed two models for the stock assessment of fisheries which only have catch data. Annual time series of catch data are more common than other types of data due to the requirement of many government statistics departments which emphasise outputs from economic sectors, and to the support from FAO and other organisations in collecting the appropriate data to report landings.

The assessment models are based on the logistic population model, but without a time series of fishing effort or an index of abundance. To fit the population model, an additional assumption has to be made on how the exploitation rate (fishing effort) develops. The most appropriate model for assessment follows a proportional change in exploitation rate (logistic effort model) and requires two economic parameters.

Dolphinfish (*Coryphaena hippurus*) is a common species in Barbados waters. There is a good catch time series going back as far as 1955, as well as effort data and capacity data. This data set should form the basis for a good test of the catch-only model as it offers a number of alternatives for the analysis. Given the extensive area the stock probably covers (the Eastern Caribbean) and partial availability of CPUE data, it is possible that a catch-based model could be used as the basis for a full stock assessment for this stock.

(ii) Parameters and Priors

The model is based on four parameters for the dynamics and a further two parameters to initiate the time series (See Table 1). The model in general needs to be fitted using Bayesian techniques, as maximum likelihood rarely has a single reliable solution. Priors can be used to keep parameters in reasonable bounds.

$$c_t = C_t / B_\infty \qquad b_t = B_t / B_\infty$$

$$b_{t+1} = b_t + r b_t (1 - b_t) - c_t$$

$$p_{t+1} = p_t \left(1 + x \left(b_t / a - 1 \right) \right)$$

Where C_t = Catch in time t, B_t = biomass in time t and p_t = exploitation rate in time t (proportion of the biomass caught). The model can be fitted to catch data, biomass indices and/or exploitation rate indices.

Table 1. Model parameters

Parameter		Comments
B_∞	Unexploited stock size	The size of the stock before fishing. In this case this will be difficult to estimate. The further back the time series goes, the better the estimate of this parameter (and b_0) will be. For the test, the area would be the fishing area (Barbados pelagic EEZ) rather than the stock area.
r	Maximum rate of increase	A prior can be obtained based on growth and reproduction parameters and information.
a	Break-even point	This is likely to occur after MSY (0.5), but would probably be above 0.1 unless prices increase with shortage of supply.
x	Rate of increase or decrease of exploitation rate	This parameter is difficult to get prior information on. Highly volatile changes in exploitation rate are unlikely, so values are likely to be between 0-0.5.
b_0	Initial stock state	With a long catch time series to the start of fishing, this parameter will be well specified. Otherwise, the assessment may become unreliable. Assuming exploitation is light at the start of the time series, values between 0.7 and 1.0 are reasonable.
p_0	Initial exploitation rate	This can be assumed fixed as catch divided by biomass at the start of the series making fitting easier.

(iii) Inter-sessional Activities

The model test should take place before the next methods working group meeting (Table 2). The assessment itself should be straightforward, but various data and priors will need to be developed.

Catch data will need to be compiled for as long a time series as possible (1955-present) for Barbados initially and other countries if the assessment proves successful. While obtaining good priors for the economic parameters is difficult, it may be possible to compile a time series index of the exploitation rate which might be used to help fit the model. The index could be based on fishing capacity for which longer time series may be available in many countries. Other data, such as fishing effort, may be available and can be used to compare this new method with more traditional approaches to assessment.

Table 2. Criteria for assessing the "catch-only" biomass dynamics stock assessment method.

1	Data Requirements / Availability / possibilities	The method primarily uses catch data. In theory, only a catch time series is required, but in practice more information is likely to be required to get a reasonable indication of stock status.
2	Type of Management Advice and objectives addressed	The model provides advice based on the MSY reference point. However, the implicit economic dynamics suggest that the model could be used to define optimal capacity as well.
3	Expected management actions	Controls on fishing effort, catch and fishing capacity would all be possible based on advice from this assessment.
4	Level of skills required	Skills required are high for developing and fitting the model.
5	Attributes of the fishery	Any where total catch is recorded
6	Cost, risks / benefits of applying a particular method	The method requires more assumptions than typical for biomass dynamics models, notably the way in which the exploitation rate changes. The method test will explore possible costs with applying the method.

IV - ParFish (Update)

In the first meeting of the ad hoc Methods Working Group, a new method suitable for stock assessment in small scale fisheries, ParFish, was proposed for testing. Trinidad and Tobago undertook to include a test of the method in their national budget. The financial resources for the test have now become available, and the test should take place in 2008. It is planned to conduct two ParFish assessments. The Trinidad and Tobago shrimp fishery already has considerable work and data put into both a stock assessment and building bridges between government and the fishers. The availability of previous assessments and data will form a good test bed for the ParFish approach, while allowing additional steps to be made in increasing the participation of fishers in the management of this fishery. It is hoped that a second fishery will be identified also to try the method. Ideally, the fishery should be small scale, self-contained (i.e. stock is not shared) and ready to undertake voluntary management controls on which ParFish would help the fishers reach a decision.

Another test is being conducted with the US deepwater snapper fishery in Puerto Rico. This will develop a yield-per-recruit approach, which could be particularly useful for implementing closed seasons where growth is a dominant factor. While the US may not adopt the approach (it has its own criteria for methods), it is hoped that the test would further improve the method for application in the Caribbean.

V - Use of Logistic Population Model with Bayesian Priors

Biomass dynamics population models can be fit to catch and effort data, which are widely available for a number of fisheries. However, it is common to have a relatively short time catch and effort series with little contrast in the data. Where CPUE and total catch have remained relatively constant, these data by themselves are uninformative on all but one of the parameters in the model. In the traditional fitting method, the model can make no use of other information, and the assessment would fail. However, there is usually considerably more information available on the biology and ecology of the species which could be used to help give reasonable ranges or probabilities for the indicators of interest (state of the stock, MSY and so on) in fitting the model using Bayesian techniques.

The logistic model was fitted to a short catch and effort time series for St. Lucia queen conch fishery at the 2007 Scientific Meeting. However, it was raised at this meeting that there was no generally accepted method for developing priors for these models. The priors used were based on the scientific literature for density and estimated abundance and rate of increase from the Turks and Caicos Islands stock assessment. This issue of developing priors also applies to the catch-only biomass dynamics model above.

At this Methods meeting, two procedures were suggested for further study. Firstly, prior probability density functions for the intrinsic rate of increase parameter (r) could be based on a population simulation using reproduction, growth and mortality models established for the species. Secondly, information on productivity and unexploited density or abundance might be re-scaled between countries based on scoring by experts similar to that used by the ERAEF approach. This latter method should give a documented, transparent ratio score allowing greater sharing of results and improvement in the reliability of advice. It is planned that both approaches might be tested before the next working group meeting.

There is sufficient information to set up a population simulation of dolphinfish for Barbados and conch for St. Lucia/St. Vincent to develop a prior of the intrinsic rate of increase. For queen conch, this can be compared to the Turks and Caicos Islands' estimate to see if it is a reasonable approach.

A scoring method could be developed to assess the comparative conch densities and productivity among St. Lucia, St Vincent, Belize and the Turks and Caicos Islands so that information from one location can be used to develop a prior for the relevant parameters in another location. Initially, the ERAEF scoring productivity attributes might be used to see whether scoring can be scaled correctly to give realistic quantitative adjustments to parameter sets.

VI- Unequal Probability Sampling Simulation

(i) Method

Three possible simple sampling approaches for collecting catch and effort data were considered for New Providence in the Bahamas and a simulation used to illustrate some of the implications of these methods. This is in preparation for testing an improved sampling system in The Bahamas so that total catches can be estimated. Formal sampling systems are not implemented in most Caribbean countries for catch and effort data monitoring. An important reason for this is the relatively poor efficiency of simple sampling systems.

As well as simple random sampling, simple stratified random sampling and the more complicated unequal probability sampling (Thompson 1992) are applied. More complex designs could be considered to cope with logistical issues such as cluster and systematic sampling. However, sampling should be kept as simple as possible. The argument for unequal probability design is that it is as close as possible logistically to the current data collection methods, but implements a formal system which would allow unbiased estimation, including estimating standard errors.

A simulation was developed to consider the sampling design. There are about 10 sites in New Providence, with the number of vessels registered at each site available from a 1995 census as an indicator of activity. All sites can be reached easily by road from Nassau. Two data collectors would be consistently available with their own transport. They could only do either a morning (early until midday) or afternoon (midday until late) period with the available working hours. During that time they can record all catches, or sufficient information to estimate the total catch landed during that time period. Data collectors can be allocated to any site on any day of the week morning or afternoon without a problem, except weekends when reduced sampling can only be conducted. For this reason, in all cases, with the exception of simple random sampling, a weekday/weekend strata were used.

The probabilities of selection and landings are set and assumed in the simulation to be proportional to the activity at the site (Table 3). The site activity was also used for stratification, with sites 10.2, 10.09 and 10.10 falling into the first and other sites into a second group. This gives 4 strata (2 site x 2 day), which reflected the big divisions between activity levels. Optimal strata allocation was not explored at this meeting.

The FAO guidelines recommended sampling effort in a month is 24 (square root of 560). Two sampling units can be allocated to the weekend, and the remaining allocated to the week days. The simulations were used to assess changes in estimate accuracy with sampling effort, and changes due to the allocation of more or less sampling over the weekend.

Table 3. Information used in the sampling design. Information consisted of the vessels found at each site in the 1995 census (sites with ID numbers 10.01-10.18), the relative expected activity from Monday to Sunday (all days the same except Sunday with only 33% of the activity) and the relative expected activity between morning and afternoon. These give 10x7x2x4=560 possible sampling units in 28 days.

Sites

10.01	10.02	10.06	10.09	10.10	10.12	10.13	10.14	10.17	10.18
7	84	23	142	105	4	46	44	4	33

Mon	Tue	Wed	Thu	Fri	Sat	Sun
0.2	0.2	0.2	0.2	0.2	0.2	0.06

Morning	Afternoon
0.4	0.6

(ii) Results

The simulation results suggest that although simple strata produces reasonable results, significant improvement could be obtained using unequal probability sampling. Unequal probability sampling is the most efficient sampling approach (Figure 1-3). There is some concern that rarely unequal probability sampling can perform badly if by chance sites with low activity only are chosen (Figure 3). Combining the 4-way stratification with unequal probability sampling would avoid this problem, as most sampling would be forced on larger sites, at the cost of a small increase in complexity. However, it is pessimistic to expect this would be a significant problem.

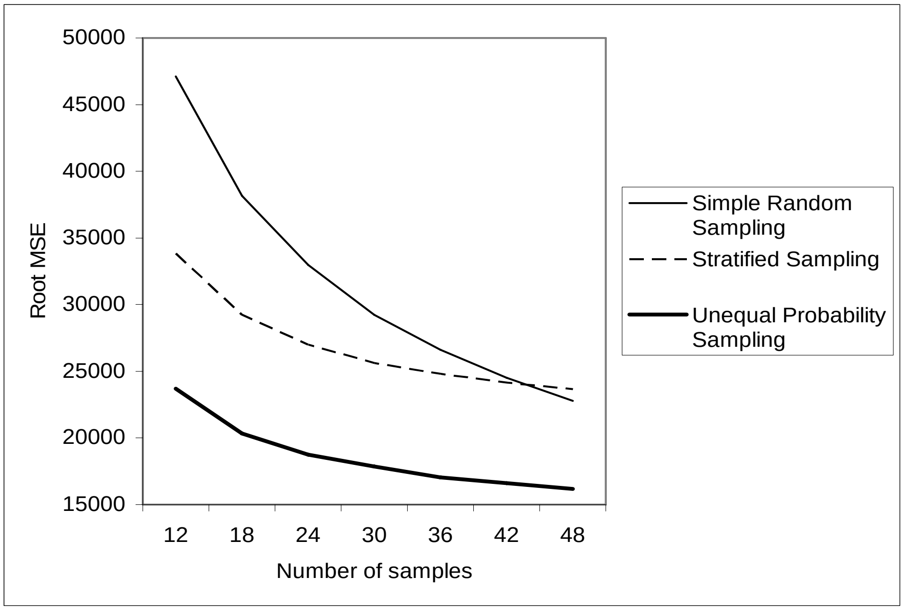

Figure 1. The simulation root mean square error for the total catch plotted against the sample size. While the estimate of total catch will improve with sample size, there are diminishing returns and 24 seems to give reasonable accuracy. Unequal probability sampling performs better than the stratified sampling which, on the whole, performs better than simple random sampling. Simple random sampling appears to perform better at higher sampling levels because it has no restrictions on weekend sampling, which is unrealistic.

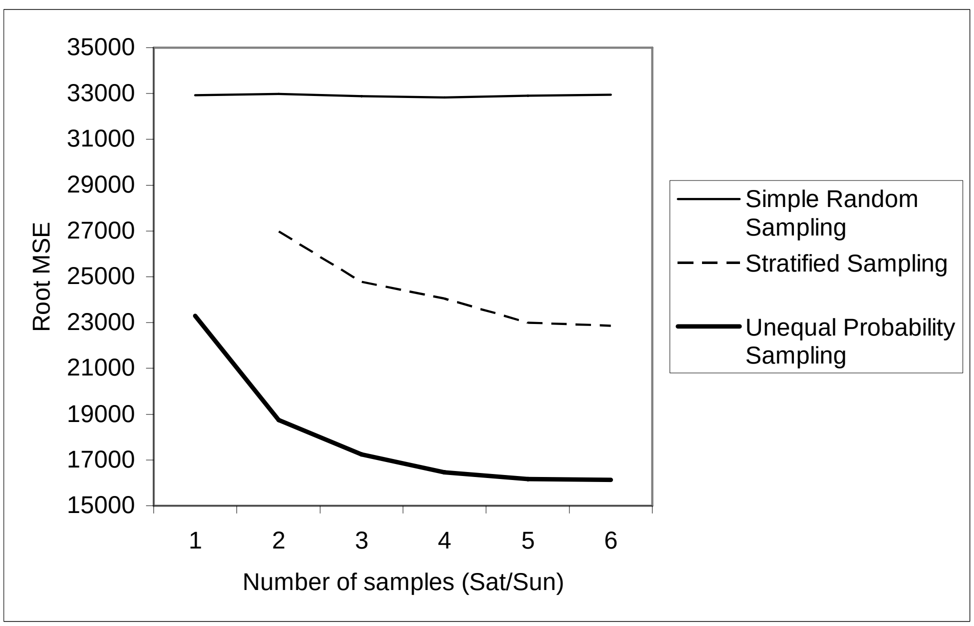

Figure 2. The effect of increasing weekend sampling by diverting sampling effort from the weekdays improves estimates to an optimum of 5. Weekend sampling is likely to be more difficult to organise, but these results suggest at least 2 per month should be undertaken. Simple random sampling is unaffected as weekends are not treated separately.

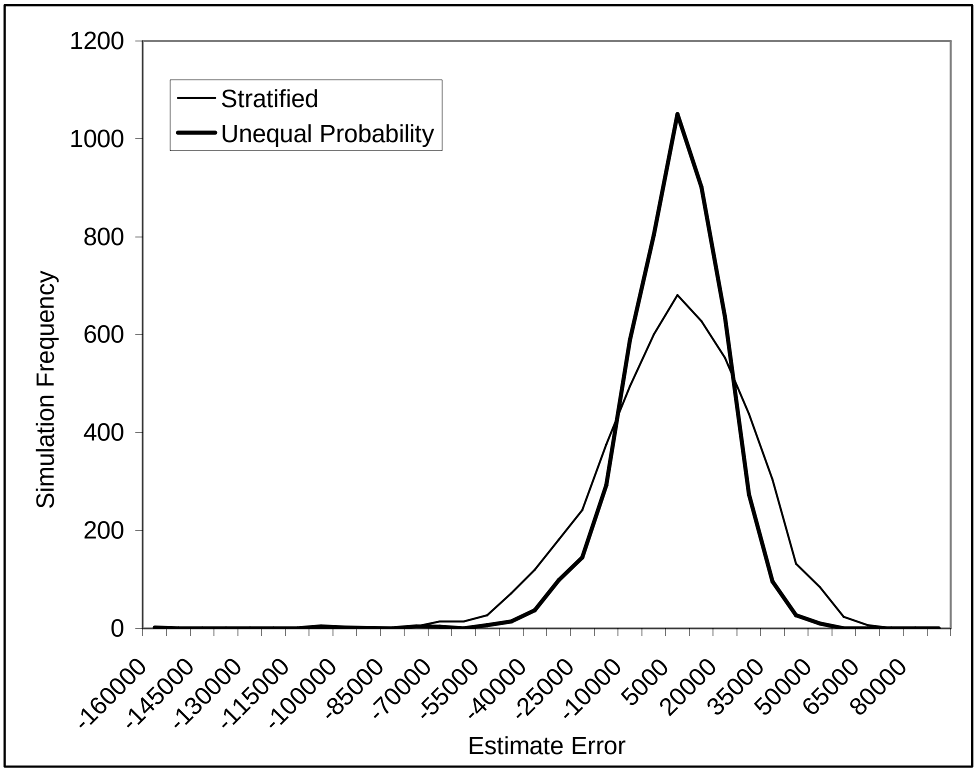

Figure 3. Simulated error for the two sampling methods demonstrates the superior efficiency of unequal probability sampling which has a lower spread of values around 0. However, although it is not clear from the graph, unequal probability sampling generated 8 estimates out of 5000 outside the maximum range generated by the stratified sampling (i.e. 8 months in 416 years of sampling). This demonstrates that rarely the unequal probability sampling will perform badly.

(iii) Inter-sessional Activities

The simulation shows that it is worth conducting a trial of the unequal probability sampling method. Unequal probability sampling with replacement is not overly complex, although some housekeeping of the probabilities used and number of times a site is selected in the sample is required. These are used in estimating the total catch. If the probabilities should change in an attempt to improve the efficiency, these changes need to be kept track of.

Where sampling is for some reason prevented (a "non-response") either the missed data is not missed for any systematic reason related to the total catch, in which case the missing data can be ignored, or some correction can be applied. For example, a missed holiday could be assumed to be more like a Sunday than any other day, and a correction applied accordingly. This issue needs to be monitored during the trial. The probabilities of selection can be used to apply the correction if they are proportional to the expected landings when data was not collected.

Two actions are required to prepare for the unequal probability sampling trial:

1. Prepare spreadsheet based software to allocate the samples by 1 week, 2 weeks or 4 weeks and using these values and the observed catches, estimate the total catch. If successful, the method could be implemented through CARIFIS which should provide seamless total catch estimates.
2. Use the available catch and effort data to provide better probabilities of site, day and time of day selection.

Once completed, these two activities could form the basis for the trial which would test the practicalities of the approach. The final test is the practicality and robustness of the method in the face of the logistical problems countries face in implementing data collection programmes.

VII - Estimation of an index of survival for spiny lobster in the Bahamas

Hoenig and Gedamke (2007) developed a method for estimating survival rate from catch rates. It generalizes an earlier method developed by Gulland (1955) by allowing data from several years to be combined. However, in the trial reported here, survival rates were calculated for each year. The survival rates were converted into instantaneous rates of total mortality (Z) and the results were compared to those obtained from length converted catch curves and the Beverton-Holt estimator based on mean length.

The survival estimator is based on the simple idea that if this year the catch rate is 100 and next year the catch rate *of the same group or cohort of animals* is 70 then the group or cohort has had a survival rate of 70%. The key ideas are that catch rate is proportional to abundance, and the recruits can be eliminated from consideration in the second year so that the abundance of one group can be tracked over time. If the new recruits cannot be identified precisely, then the method provides biased estimates of survival. However, these biased estimates may still be valuable for tracking trends in survival rate over time.

The method was applied to spiny lobster in the Bahamas. Catch rate data were obtained for two gear types (lobster hooks and spearing) for the fishing seasons 1999/2000 through 2006/2007. However, the data prior to the two most recent years are of questionable quality. Because the data are recorded by market category, rather than being based on measurements of carapace lengths, it is not possible to eliminate the recruits from a sample in a precise way. Instead, we had to disregard the smallest market category in the second year on the assumption that the first market category constituted the new recruits.

It is apparent that the estimates from the two methods based on length composition are very similar in their trends over time (Figure 1). And, the catch rate based method provides similar results for the two gear types. However, the length based methods provide estimates of total mortality that are much higher than the catch rate based method. The length based methods appear more credible for the following reason: the natural mortality rate, M, is believed to be about 0.35 yr^{-1}; subtracting this from the values of Z obtained from the catch rate method results in some estimates of fishing mortality that are negative which is not credible.

It is notable that the length based methods and the catch rate based method show little trend in estimated mortality rate over time except for the last two years when both approaches indicate a drop in mortality rate.

It is concluded that the length-based methods are providing more credible estimates of the absolute mortality rates, although the reliability of the estimates is uncertain because of unknown reliability in the growth parameters used in the calculation of mortality rate. The catch-rate based method may be providing an index of mortality rate, i.e., may be showing the trend in mortality even if it does not specify what the mortality rate might be.

The catch rate method is designed to be used in cases where new recruits can be eliminated from consideration on the basis of their being identified by their size. It may work well for fish species where length sampling is conducted. Application to spiny lobster, where the size composition of the catch is known poorly, is problematic. However, the approach may be useful for detecting trends in mortality rate over time.

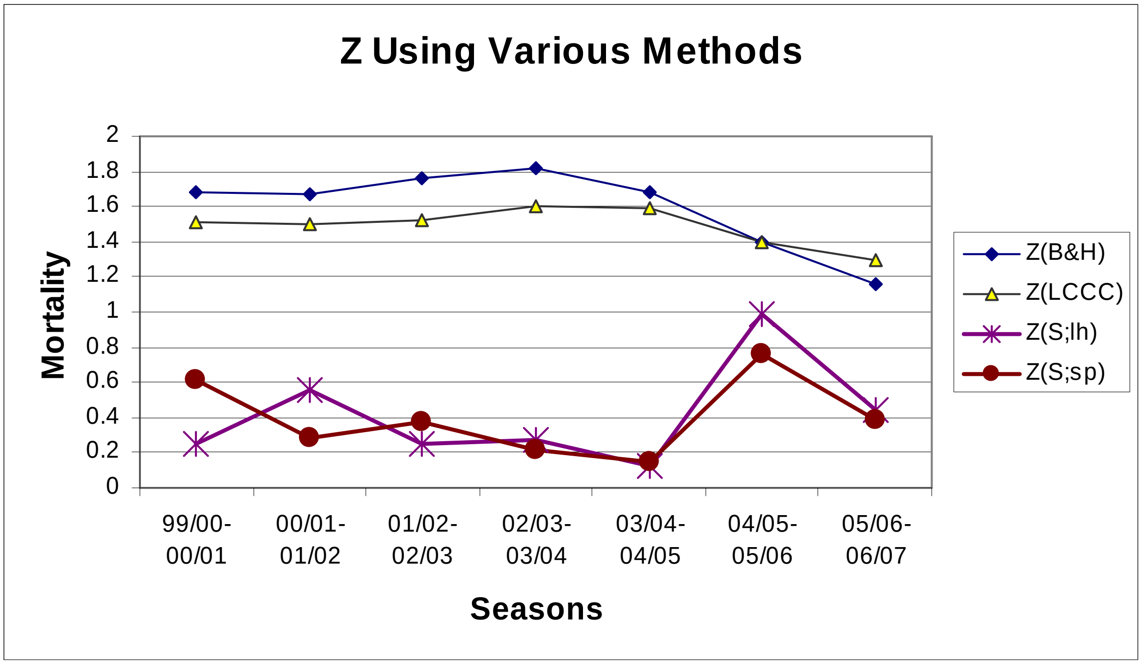

Figure 1. Estimates of total instantaneous mortality rate, Z, for spiny lobsters in the Bahamas obtained by four methods. Z(B&H) = Beverton and Holt method based on mean length; Z(LCCC) = length converted catch curve; Z(S;lh) = Z obtained from estimate of survival obtained by the catch rate method for lobster hook data; Z(S;sp) = Z obtained from estimate of survival obtained by the catch rate method for lobster taken by spearing.

IX - Methods to be tried in the joint assessment of Suriname – Guyana seabob in 2008

The following constitutes the analytical approaches that will be attempted for assessment of the seabob resource. Some of these approaches may prove to be unfruitful but it is hoped that enough of them will work to provide valuable advice on the status of the stock.

1) Develop growth curves by looking at modes or peaks in a series of length frequency graphs over time.
2) Develop catch rate indices of abundance to look at changes in abundance over time for two age groups (recruits and post-recruits)
3) Estimate mortality rate using:
    a. Length-converted catch curve
    b. Beverton-Holt formula based on mean length
    c. Gedamke-Hoenig method based on estimates of mean length for a series of years
    d. Hoenig-Gedamke method based on catch rate data for a series of years
4) Evaluate the effects of various kinds of seasonal closure (or restriction) on shrimp yield by modeling the seasonal change in biomass. Biomass changes due to growth and mortality and these quantities will be estimated.
5) Examine trends in abundance of mature shrimp (i.e., develop index of spawning stock biomass)
6) If mortality rates cannot be estimated, then attempts will be made to examine trends in mortality (is it going up or down) and to quantify relative changes (i.e., by what percentage did it change)

X - Plans for 2008 assessment of Guyana grey snapper

Data:
We will look at whatever data are available. In particular, we will look at how the size composition of the catch has changed over time, how CPUE for two size groups (recruits and post-recruits) has changed over time, and how landings have changed over time. If possible, we will also look at rainfall data.

Uses of the data:
Length frequencies - We will try to follow modes (peaks) in length frequency distributions over time in order to determine growth rates and identify age groups.

Once we have growth parameters and age information, we will try to estimate the total mortality rate for each year using a variety of techniques including

Length converted catch curves
Beverton-Holt estimator based on mean length
Gedamke-Hoenig estimator based on mean lengths observed over several years

CPUE data. We will try to examine the catch per unit effort over the years for two size groups representing recruits and post-recruits. This method was recently published by Hoenig and Gedamke.

Rainfall data. The seasonal patterns in landings and catch rates might be affected by the timing and magnitude of rainfall. By considering rainfall, we might be able to account for some variability in landings and catch rate and thus have a clearer picture of what are the trends in abundance and mortality.

Goals. Thus, the goals are to answer the questions:
What are the mortality rates?
Have they changed over time?
Are they very high or not?
If the stock is overfished, the above results will be helpful in determining to what extent fishing should be reduced.

Data extraction:
We need a graph of length frequencies for each month in each year. The range of sizes indicated on the x-axis should be constant for every graph. The length frequencies should be tallied over bins or intervals with a 3 cm width. Additionally, the data should be tallied for 2 cm wide length bins. (It is understood that there will be some gaps in the length sampling over time and some samples may have very few fish included.)

We also need to get the catch per unit effort for each year (and preferably by month within the year) and then to divide those catch rates into two parts: catch rate of recruits and catch rate of post-recruits.

Rainfall and river flow of the largest rivers should be tabulated by month of the year for each year for which there are landings data.

If monthly price data are available for grey snapper, it may be possible to examine how landings are related to prices. This may help explain the pattern in landings over time and separate changes in landings due to changing abundance from changes in landings due to changes in prices.

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Appendix 4 – Proposal for the Continued Collaboration between the Regional Fish Age and Growth Laboratory at the Institute of Marine Affairs (IMA) and the Caribbean Regional Fisheries Mechanism (CRFM) for the Period 2008-2013

EXECUTIVE SUMMARY

Recognizing the common interest of the Caribbean Regional Fisheries Mechanism (CRFM) and the Institute of Marine Affairs (IMA) in providing information for sustainable development and management of the fisheries of the Caribbean region, these two parties agree to undertake a Letter of Agreement (LOA) to strengthen and enhance operations of the Fish Age and Growth Laboratory located at the IMA to provide scientific information for member states of CARICOM. This laboratory shall be jointly supported by the IMA and the CRFM for the period of 5 years from the execution of this Agreement.

This proposal seeks to duplicate a similar arrangement the IMA had established with the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) in 1995 for the development of a Regional Fish Age and Growth Laboratory at the IMA in Trinidad. Under this Agreement, financial resources were provided by CFRAMP and the IMA supplied the necessary facilities and expertise for the strengthening and operation of the Laboratory. The functions of the Laboratory were to produce age estimates of commercial fish species as well as corresponding growth curves and growth parameter estimates.

Preliminary age estimates were provided for 19 of the 20 species received by the Laboratory. There was varying clarity in the annuli patterns seen on the hard-parts. Growth parameter estimates were developed for eleven species. Most of these parameters can be treated as preliminary because the data set was very limited, however for two species, the Wahoo and the Crevalle Jack; reasonable good growth parameters have been developed. The limitations of the growth parameters in most cases were because the size range of the fish from which the hard-parts were collected was fairly narrow resulting in either not enough young or old fish present in the data analysis which affected the quality of many of the growth parameters. For several of these species it was the first time that age estimates and growth parameter estimates were derived from hard-parts in the English-speaking Caribbean.

Since the termination of funding from CFRAMP in 1998, the IMA has continued to support the Fish Age and Growth Laboratory financially through the continued procurement of equipment and personnel as well as training. The Fish Age and Growth Laboratory is a significant part of the Fisheries and Aquaculture research program at the IMA. The Laboratory has continued to conduct research for species submitted under the CFRAMP program and has presented these results ad-hoc at several scientific meetings of the CRFM.

In this new proposal thirteen (13) species have been identified for age and growth assessment based on a review of the CRFM Plenary Session Reports for 2006 and 2007. This is a provisional list and is subject to change based on further inputs from the CRFM and participating countries. Given the number of species to be aged over the next 5 years, the Laboratory will provide age and growth parameters for at least 2 species per year. This strategy also allows each country to focus its limited resources on collecting samples for at least one species over a one to two year period.

For each species the following will be provided:

- Age and growth information
  - age estimates (based on whole and/or section),
  - validation of annuli growth patterns on appropriate hard-part using marginal increment analysis,
  - growth curves,
  - growth parameters estimates,
  - age length keys
- Technical report (both the country and the CRFM would receive a copy)

Given the time that has elapsed between the CFRAMP initiative and that of the CRFM, it is recommended that a training workshop be conducted for field sampling supervisors (inclusive of Fisheries Officers) and data collectors. It is proposed that Laboratory staff at the IMA conduct these training sessions in the respective countries so that as many individuals as possible can be trained in each country as well as for the added benefit of Laboratory staff gaining greater insight into each target fishery. The training sessions can be staggered to coincide with the start of each country's sampling period.

It is proposed that the laboratory be staffed with a minimum of 2 fisheries biologists and one technician hired by the IMA. The IMA will continue to provide in-kind contribution through the provision of salaries for research and technical staff and new age and growth laboratory facilities which is currently under construction. The CRFM would provide funding for minor laboratory equipment and consumables, additional training for research staff and assist in establishing linkages with other fish age and growth laboratories.

Through the provision of age and growth information for stock assessments and capacity building, the IMA can be a valuable partner in regional fisheries management.

The Fish Age and Growth Laboratory at the IMA is the only facility of its kind in the English-speaking Caribbean providing such services. It is a nucleus or focal point for expertise in age and growth research. The IMA is currently being integrated into the University of Trinidad and Tobago (UTT). The University of Trinidad and Tobago envisions both Marine Research and Marine Education being offered at its Marine Research facilities. This would allow for further opportunities by the enrolment of students from the Caribbean for post-graduate degrees and attachments thereby building capacity in this research area.

1. BACKGROUND

The CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) and the Institute of Marine Affairs (IMA) signed a Letter of Agreement in January 1995 for the development of a Regional Fish Age and Growth Laboratory at the IMA in Trinidad. Under this Agreement financial resources were provided by CFRAMP and the IMA supplied the necessary facilities and expertise for the strengthening and operation of the Laboratory.

In 1994, under the CFRAMP Subproject "Large Pelagics, Deep-Slope and Reef Fishes Resource Assessment", participating countries identified a total of sixteen (16) species for ageing using hard-parts by the Fish Age and Growth Laboratory. In addition, several more species were added resulting in a total of twenty (20) species to the list Annex 1, excluding species specific to the Alice Shoals Project, Jamaica. The function of the Laboratory was to produce age estimates of those species as well as corresponding growth curves and growth parameter estimates.

Status
Samples from twenty (20) species were received by the Laboratory. Age estimates were provided for nineteen (19) of the species, Annex 2 based on presumed annuli from hard-parts; sectioned and whole sagittae and sectioned spines. There was varying clarity in the annuli patterns seen on the hard-parts. For several of these species it was the first time that age estimates and growth parameter estimates were derived from hard-parts in the English-speaking Caribbean.

Some species were relatively easy to age such as the lane snapper *Lutjanus synagris*, whilst others such as the Kingfish *Scomberomorus cavalla* was difficult and no reliable age estimates have been developed for this species. No discernable annuli pattern was determined for the black fin tuna *Thunnus atlanticus* despite using both whole and some section otoliths and this assessment together with Kingfish has to be re-examined. With the exception of the Wahoo *Acanthocybium solandri*, all ages were based on sectioned hard-parts.

Growth parameter estimates were developed for eleven species. With the exception of the Wahoo and Crevalle Jack, most of the parameters can be treated as preliminary because the data set was very limited. In most cases, the size range of the fish from which the hard-parts were collected were fairly narrow resulting in either not enough young or old fish or the complete absence of some age groups in the data set which affected the reliability of many of the growth parameters. Annex 3 details the results of each age and growth assessment and its limitations as well as a status of all the reports and presentations conducted.

2. JUSTIFICATION

Stock production is a mixture of recruitment of juveniles to the populations and the growth of the individuals already recruited to the stock. This is one reason there is a huge quantity of literature on the growth of individuals in fisheries ecology. In addition, many aspects of a species' life history characteristics tend to be reflected in how it grows (Haddon 2001). Age information forms the basis for calculations of growth rate, mortality rates and productivity, ranking it among the more influential of biological variables (Campana 2001).

Traditionally in the English-speaking Caribbean, growth information for stock assessment has come from length-based methods. However such length-based assessment is dependent on the identification of clear modes within the population. The use of size-selective gears makes modal progression which is necessary for growth analysis, difficult and sometimes impossible. Hoggarth et al. (2005) noted that where ages can be estimated directly (from hard-parts) this will usually give more reliable estimates of mortality rates indicators than any of the length-based methods. In North America, Europe and Australia, many of the stock assessments of commercial catches is based upon age estimates from hard-parts and there are well established age and growth laboratories attached to government agencies and universities.

The fisheries sub-sector within the Caribbean is very important both economically as well as for the social stability it brings to many of the coastal and rural communities. There is a high level of uncertainty regarding the status of the fisheries resources in the region due to high species diversity, complex overlapping stocks, limited scientific information and inadequate management capacity (UNEP 2005). Resource assessment and management of fisheries resources has been identified as one of the priority areas by the CRFM in their Strategic Plan (CRFM 2002). As part of the required and available competencies to address these priorities, the CRFM has also identified several national and regional organisations that could become part of the mechanism either because of their current activities which are relevant to the priority programs or their mandates and organizational plans and competencies such as the IMA (Ibid.).

Since the termination of funding from CFRAMP in 1998, the IMA has continued to support the Fish Age and Growth Laboratory financially through the continued procurement of equipment and personnel as well as training. The Fish Age and Growth Laboratory is a significant part of the Fisheries and Aquaculture Research Program (F&ARP) at the IMA. The Laboratory has continued to conduct research for species submitted under the CFRAMP program and has presented these results ad-hoc at several scientific meetings of the CRFM.

The IMA has thus built a level of expertise for fish age and growth research for reef and pelagic fish species. Given the need for age and growth information from hard-parts identified by the CARICOM countries for stock assessment, it is proposed that a similar agreement be established between the IMA and the CRFM.

Recognising the common interest of CRFM and the IMA in providing information for sustainable development and management of the fisheries of the Caribbean region, these two parties agree to undertake an Agreement to strengthen and enhance operations of the Fish Age and Growth Laboratory located at the IMA to provide scientific information for member states of CARICOM. This laboratory shall be jointly supported by the IMA and the CRFM for the period of 5 years from the execution of the Agreement.

3. STATEMENT OF WORK AND SERVICES

3.1 Identification of Target Species

Identification of the following species was based on a review of the plenary session reports from the 2nd and 3rd CRFM Scientific Meetings in 2006 and 2007, Table 1. This is a provisional list which is subject to change based on further inputs from the CRFM and participating countries.

Table 1: Proposed species for age and growth studies under the CRFM/IMA Agreement for the period 2008 – 2013

	Country	**Species**
Large Pelagics	Trinidad & Tobago, Barbados, St. Vincent, St. Lucia, Grenada,	*Acanthocybium solandri* (Wahoo)*
	Trinidad and Tobago	*Scomberomorus cavalla* (Kingfish)
	Trinidad and Tobago	*Scomberomorus brasiliensis* (Spanish mackerel)**
	Trinidad and Tobago	*Caranx hippos* (Crevalle jack)*
Groundfish	Guyana	*Lutjanus purpureus* (southern red snapper)
	Guyana	*Macrodon ancylodon* (king weakfish or bangamary)
	Trinidad & Tobago, Belize	*Lutjanus synagris*, lane snapper
	Trinidad and Tobago	*Micropogonias furnieri*

		(yellow mouth croaker)
	Guyana	*Cynoscion virescens* (seatrout)
Reef and Slope	Belize	*Lutjanus analis* (mutton snapper)
	Belize	*Epinephelus striatus* (Nassau grouper)

* *Current research to be completed in 2008*

** *Some work completed for 95-96, data set to be expanded to cover 91-96*

3.2 Additional species:

The two species listed here were based on an incomplete age and growth assessment for the Blackfin tuna and initial discussions with the representative from Barbados for the 'triggerfish' at the 3rd CRFM Scientific Meeting in 2007.

	Country	**Species**
Large Pelagics	St. Vincent	*Thunnus atlanticus* (Blackfin tuna)
Deep-Slope	Barbados	*Canthidermis maculatus* (Turpit)

In summary thirteen species (13) have been identified for age and growth assessment. The provisional lists above have to be finalised and approved by the CRFM and the relevant countries. Also included in the lists are species for which age and growth assessments are currently being conducted.

3.3 Details and scheduling

The Laboratory will be responsible for the management of fish age and growth data. It is recognised that this is a time-consuming exercise, involving data collection, sample processing, age determination and data analysis. Additionally, archiving and storing of processed hard part samples and database development for storing of computerised data and digital images inclusive of reference collections, will form part of the Laboratory methodology protocol. An Access database is currently being designed to house the data.

Given the thirteen (13) species to be aged over the next 5 years, the Laboratory will provide age and growth parameters for at least 2 species per year. Due to the limited resources (both financial and human) in the respective countries for sample collection as well as for the Laboratory at the IMA, it is envisaged that the assessments will be done on a phase/staggered basis. This recommendation is based on previous experience under the CFRAMP/IMA Agreement when small number of samples for many species were collected resulting in limited growth parameters and in many cases none, despite discernable and in some cases very clear growth patterns on the hard parts. This strategy would also allow each country to focus its limited resources on collecting samples for at least one species over a one to two year period.

3.4 Sample Collection

For each species it is suggested that at least 50 individuals are collected each month for at least one year. In addition, samples must cover the entire size range, particularly larger individuals, for the generation of reliable growth parameters. Samples not captured from the commercial catch may be collected from fishery-independent sources such as fishery-independent surveys. Many species exhibit sexually dimorphic growth patterns hence samples must be sexually differentiated. The Laboratory and the country involved would work together to determine an appropriate sampling strategy. It is envisaged that the sample collection would be well advanced before the age analysis commences.

For new species which have never been aged, an evaluation of the hard-parts is first needed to select the best or most appropriate for ageing. To this end, hard-parts (3 pairs of otoliths, spines, vertebrae and opercular bones) from twenty (20) large individuals are required prior to routine sample collection.

3.5 Laboratory Management

As part of the management of the Laboratory several tasks will be performed: acquisition and compilation of relevant literature, development and prioritising of work plan and schedule, compilation of reference collections and corresponding descriptive bio-profiles, archiving samples and equipment maintenance. In addition, a Laboratory operations manual will be developed. A system for long-term storage of hard-parts has to be developed.

3.6 Outputs

For each species the following will be provided:

- Age and growth information
  - age estimates (based on whole and/or section),
  - validation of annuli growth patterns on appropriate hard-part using marginal increment analysis,
  - growth curves,
  - growth parameters estimates,
  - age length keys
- Technical report (both the country and the CRFM would receive a copy)

Please note in the provision of these outputs it is recognised that some species may not have interpretable age and growth patterns.

3.7 Training

Given the time which has elapsed between the CFRAMP initiative and that of the CRFM, it is recommended that a training workshop be conducted for field sampling supervisors (inclusive of Fisheries Officers) and data collectors. It is proposed that Age and Growth Laboratory staff conduct these training sessions in the respective countries so that as many individuals as possible can be trained as well as for the added benefit of Laboratory staff gaining greater insight into each target fishery. The training session can be staggered to coincide with the start of each country's sampling period.

The Training workshop will take place over a two-day period and will not only provide training in hard part extraction procedures, but be used to nurture a greater appreciation for fish age and growth studies including laboratory procedures and the generation of growth curves and growth parameters. At least one field visit to a landing site will be required to train personnel to work in situ and allow personnel from the Fish Age and Growth Laboratory to gain a better appreciation of the target fishery.

The workshop could also include training in reproductive assessments which will include sexing and the identification of reproductive stages and the use of this information in fisheries management (See 4.0). If required, this would extend the workshop to three (3) days. These training workshops will be funded by the CRFM.

3.8 Resources

3.8.1 Personnel

It is proposed that the laboratory be staffed with a minimum of two (2) fisheries biologists and one (1) technician hired by the IMA. The functions of the researchers are to conduct age and growth analysis for the species identified and to assist in data collection where relevant (e.g. Wahoo). One of the research staff will act as the scientific leader of the laboratory. The function of the scientific leader would be to supervise quality control protocols, implement otolith exchanges where possible in preparation for otolith reference collections, direct validation studies and supervise staff of the laboratory. The functions of the technician are to assist in data collection, process samples and data entry.

3.8.2 Office and Laboratories

The current facilities of the Age and Growth Laboratory include; office furniture and space for two researchers, laboratory for image age analysis including stereomicroscope, compound microscope, 3 computers, Optimas 5.1 and Optimas 6.2 image software, analogue camera, storage for otoliths and a wet laboratory for otolith removal and processing and includes a freezer.

In addition, new fish age and growth facilities are under construction in a new research building at the IMA.

3.8.3 Equipment

IMA will contribute the following:

- 1 Low Speed Saw
- 2 lapidary polishing wheels
- Image software (Image pro-Plus to replace discontinued Optimas)
- Image hardware (computer, digital colour camera)

Additional minor equipment will be funded by the CRFM.

4. ADDITIONAL RELATED BIOLOGICAL RESEARCH

The IMA possesses the capability to assess the reproductive biology of fish with at least one of the researchers in the Fish Age and Growth Laboratory having experience in this area and with the development of its Fish Health and Histology Laboratory. Such assessments will provide added benefits for not only age and growth studies but also for other biological studies. The respective contributors, CRFM and IMA can take this under consideration.

5. REPORTING

The IMA will provide CRFM with quarterly reports and financial statements regarding the operations of the laboratory. The CRFM Secretariat will be the agent for monitoring technical progress and interacting with technical personnel of the laboratory. All requests for information and samples will be channelled via the Secretariat.

6. COLLABORATION

It is envisaged that the Fish Age and Growth Laboratory will continue to attend the CRFM Scientific Meetings to disseminate information as well as to obtain feed-back from the respective countries. The CRFM and the IMA will also pursue linkages with other age and growth laboratories with the aims of training of research staff of the Fish Age and Growth Laboratory and standardising research methodologies and protocols, where possible to facilitate otolith exchanges.

Attachments at the identified Laboratories will provide general training on methodologies used for processing sectioned hard-parts, annuli determination, marginal increment analysis for validation as well as other validation techniques and age and growth analysis.

Some identified laboratories include Panama City Laboratory, Southeast Fisheries Center, National Marine Fisheries Service (kingfish, lane snapper and mutton snapper) and Age and Growth Laboratory at the Florida Marine Research Institute of the Fish and Wildlife Research Institute (Crevalle Jack, kingfish, wahoo, lane snapper, mutton snapper). Another reputable laboratory identified is the Otolith Research Laboratory, Bedford Institute of Oceanography, Canada where the chief scientist is Dr. Steven Campana. Dr. Campana provided training to personnel of the Age and Growth Laboratory in sample processing and annuli interpretation. Although this laboratory works on temperate species, the methodologies used are similar and importantly the image software used at the Bedford Institute is the same as the one which this Laboratory will acquire, a very important consideration in collaboration. Another important consideration with experience in tropical or closely related species is the South Australian Research and Development Institute (SARDI) where a key contact is Dr. Anthony Fowler, Sub-program Leader of the Marine Scale fish Program.

The attendance of research staff of the Laboratory at regional and international symposia and workshops will be encouraged to keep abreast of the latest technologies in fish age and growth research.

7. SUMMARY OF BENEFITS

The Fish Age and Growth Laboratory at the IMA is the only facility of its kind in the English-speaking Caribbean providing such services. It is a nucleus or focal point for expertise in age and growth research. The IMA is currently being integrated into the University of Trinidad and Tobago (UTT). The University of Trinidad and Tobago envisions both Marine Research and Marine Education being offered at its Marine Research facilities. This would allow for further opportunities by the enrolment of students from the Caribbean for post-graduate degrees and attachments thereby building research capacity in this area.

Through the provision of age and growth information for stock assessments and capacity building the IMA can be a valuable partner in regional fisheries management.

8. BUDGET

The IMA will continue to provide in-kind contribution through the provision of salaries for research and technical staff, Laboratory facilities including office equipment. Table 2 identifies the proposed contribution by each member of the Agreement.

Table 2 - Proposed budget for the Age and Growth Laboratory for the period 2008 – 2013.

Category	ITEM	Contributing Organizations	FY 08/09-	FY 09/10-	FY10/11-	FY 11/12-	FY 12/13	Total $US
Human resources	Two Fisheries Biologists (post-graduate level)	IMA	IMA	IMA	IMA	IMA	IMA	
Human resources	One Technician (A level)	IMA	IMA	IMA	IMA	IMA	IMA	
Equipment	One Isomet Low Speed Saw	IMA	$4, 000					$4,000
Equipment	Image Analysis Software	IMA	$10, 000					$10, 000
Equipment	One Computer	IMA	$2, 000					$2, 000
Equipment	One Printer and accessories	CRFM	$1, 000		$250		$250	$ 1, 500
Equipment	Digital Camera	IMA	$10, 000					$10, 000
Equipment	2 Lapidary Machines	IMA	$600		$600			$1, 200
Equipment	Dissecting Equipment & Storage trays & boxes, Micromounts	CRFM	$2,500		$2,500			$5, 000
Consumable Equipment	Gelatin Capsules, embedding medium, blades for saws, embedding molds, Carbimet Discs,	CRFM	$1,000		$1,000	$1,000		$3, 000
Office and Laboratory Furniture		IMA	IMA					
Training	(6?) Training Workshop for Data Collectors and Supervisors in respective countries [1]	CRFM (2 workshops per year)	$5,000	$5,000	$5,000			$15,000
	Image Analysis software training	IMA	$5,000					$5,000
	Training attachment at Southeast Fisheries Centre	CRFM		$30, 000				$30, 000
	Collaboration with other	CRFM		$10, 000	$2,500	$2,500		$15, 000

	Laboratories (attachments, otolith exchange)							
Travelling	Attendance at Age and growth symposia and workshops	CRFM	CRFM					$25, 000
Travelling	Attendance at CRFM Workshops	CRFM	$1,000	$1,000	$1,000	$1,000	$1,000	$5, 000
	Total							**$131,700**
	Total + 10% Contingency							**$144,870**

1 training materials to be provided by the IMA and respective countries to provide training facilities and samples required for Workshop

9. References

Campana, S.E. (2001). Accuracy, precision and quality control in age determination including a review of the use and abuse of age validation methods. *Journal of fish biology 59*:197-242 doi: 10.1006/jfbi.2001.1668.

CRFM (2002). Strategic plan for the Caribbean regional Fisheries Mechanism. CARICOM Fisheries Unit. 9th December 2002. 141p

Haddon, M. (2001). Modelling and quantitative methods in fisheries. Chapman and Hall, USA. 404p.

Hoggarth, D.D., Mees, C.C., O'Neill, C., Hindson, J., and Krishna, M. (2005). A guide to fisheries stock assessment using the FMSP tools. Marine Resources Assessment Group (MRAG), London Centre for Environment Education, Ahmedabad, Scales Consulting ltd. London. 62p

UNEP (2005). Caribbean environmental outlook. Special edition for the Mauritius international meeting for the 10-year review of the Barbados Program of Action for the Sustainable Development of Small Island Developing States. UNEP Nairobi. 114p

Annex 1. List of species requested for ageing (Large pelagics, Reef, Deep Slope species) under the CFRAM Program.

SPECIES	COUNTRY REQUESTING AGEING													
	Antigua Barbuda	Barbados	Belize	Dominica	Grenada	Guyana	St. Vincent	Grenadine s	Jamaica	Alice Shoals	Montserrat	St. Kitts/Nevi	St. Lucia	Trinidad & Tobago
Acanthocybium solandri		X					XX						X	XX
Scombermorus cavalla												X		X
Thunnus atlanticus		X					X		X					
Caranx hippos												X		X
Sparisoma viride	X							X						
Holocentrus adscensionis				X				X		XXX				
Holocentru rufus				XX										
Balistes vetula			X					X			X			
Haemulon flavolineatum	X							X						
Haemulon melanurum										XXX				
Haemulon parrai										XXX				
Haemulon plumieri										XXX				
Acanthurus chirurgus				X				X			X			
Etelis oculatus	X	X			X							X	X	
Lutjanus synagris			XX	X						XXX				
Lutjanus jocu														X
Lutjanus vivanus	X	X								XXX				
Lutjanus analis	X													
Lutjansu bucanella				XX						XXX				
Lutjanus mahogoni			X	X				X						
Pristopoimoides										XXX				
Epinephelus cruentatus				XX										
Epinephelus fulvus				X						XXX		X		
Epinephelus guttatus	X		X		X					XXX				
Macrodon ancylodon						XXX								
Ocyurus chrysurus			XX											

X – Species from original 1995 Letter of Agreement XX – Species added to original list XXX – Alice Shoals species

Annex 2: Samples received under the CFRAMP Biological Data Collection Program for ageing using hard-parts.

Species	FAO Common Name	Total samples Received	Samples Aged	Annular Interpretation
Acanthocybium solandri	Wahoo	Barbados – 62 St. Lucia - 77 St. Vincent – 157 T&T - 531	771 - (whole)	Reasonably clear growth patterns seen on the whole sagitta of this species. No discernable annuli present on sectioned otoliths.
Acanthurus chirurgus	Doctorfish	Montserrat – 164	120 (whole) 120 (section)	Difficult to age. Annuli patterns on sectioned sagitta were diffuse in the younger age groups and the first annulus was difficult to discern. Older fish were relatively easier to age because the banding patterns were more definitive.
Balistes vetula	Queen triggerfish	Montserrat - 220	207 (sectioned spines)	Reasonably clear growth patterns seen on the sectioned spines of this species. In older fish the central canal tends to be obliterated, which makes the position of the focus and the first annulus often difficult to determine.
Caranx hippos	Cavali, jack	Trinidad - 332	309 (whole) 307 (section)	Reasonably clear growth patterns seen on the whole and sectioned sagitta of this species. Position of the first annulus difficult to determine on the whole but less difficult to define on the section.
Cephalopholis cruentata	Graysby	Dominica - 35	29	Reasonably clear growth patterns seen on the sectioned sagitta of this species
C. fulva	Coney	Dominica – 48	28	Reasonably clear growth patterns seen on the sectioned sagittae of this species
Epinephelus guttatus	Red Hind	Grenada – 57 Dominica - 13	43	Annuli growth patterns on sectioned sagitta were more diffuse and difficult to interpret than those subsequently formed.
Etelis occulatus	Queen Snapper	St Lucia - 29		
Haemulon plumieri	White grunt	Antigua - 4	4 (whole)	
Holocentrus	Squirrelfish	Dominica – 106 + 69*	98 (section)	A relatively clear pattern of alternate light and dark bands

Species	FAO Common Name	Total samples Received	Samples Aged	Annular Interpretation
adscensionis				corresponding to opaque and translucent bands were observed on the sections of this species.
H. rufus	Longspine squirrel fish	Dominica – 166 + 111*	153 (section)	A relatively clear pattern of alternate light and dark bands corresponding to opaque and translucent bands were observed on the sections of this species
Lutjanus analis	Mutton snapper	Belize - 3	2 (whole)	Relatively clear annuli patterns present on sectioned sagittae
Lutjanus buccanella	Blackfin snapper	Dominica - 53	36 (whole)	Relatively clear annuli patterns present on sectioned sagittae
L. mahogoni	Mahogany snapper	Dominica - 51	41 (whole)	Relatively clear annuli patterns present on sectioned sagittae
L. synagris	Lane snapper	Belize – 91	88 (section)	Clear annuli patterns present on sectioned sagittae.
L. vivanus	Vermillion snapper	Dominica – 60 Antigua - 15 Barbados - 2	56 (section) 15 (whole)	Clear annuli patterns present on sectioned sagittae
Macrodon ancylodon	King weakfish	Guyana - 8		No discernable growth patterns seen on sectioned sagittae
Ocyurus chrysurus	Queen snapper	Belize - 13	12 (whole)	Relatively clear annuli patterns present on sectioned sagittae
Scomberomorus cavalla	Kingfish	T&T - 250 (177) collected for microstructure analysis	250(whole) 134 (section)	Diffuse growth patterns for younger fish makes it difficult to age fish both on whole and sectioned otoliths.
Thunnus atlanticus	Blackfin tuna	St. Vincent - 158	56 (whole) 20 (section)	Tentative age estimates assigned because of uncertainty of annuli patterns on sectioned and whole otoliths.

* These samples were sent to the Laboratory in March 2002. Due to problems with the embedding medium (only rectified in June 2003) no processing was done on these samples and the age analysis was already completed by researchers who have since left the Laboratory.

Annex 3: Growth parameter estimates for commercial species in the Caribbean generated by the Fish Age and Growth Laboratory.

Species	Country	Asymptotic Length L_{∞}(cm)	Growth Constant K (year^{-1})	t_o (years)	Sample Size (n)	Limitations/Comments	Status Reports/Presentations
Acanthocybium solandri	Trinidad and Tobago, St. Vincent, St. Lucia and Barbados	155.21 (FL)	0.316	-1.172	517	Growth curve based on observed mean length at age data. Whole sagittae used for age estimates	Kishore, R. and Chin, X. 2001. "Age and Growth Studies at The CFRAMP/IMA Regional Age And Growth Laboratory – Progress of Work Done and Future Approaches" presented at the 2000 Caribbean Pelagic and Reef Fisheries Assessment Workshop. Kishore, R. 2002a. "Age and growth studies of the Wahoo, *Acanthocybium solandri* (Curvier 1830) from the Southern Caribbean". Oral presentation at the Joint Meeting of the CRFM Pelagics and reef Fisheries Working Groups (2002). All samples have been aged for data set collected from 1995 to 2003. Some statistical analyses to be completed for this assessment.
Acanthurus chirurgus	Montserrat	33.43 (TL)	0.086	-5.79	116	Sectioned sagittae used for age estimates Small data set Very narrow size range - 70% came from one 5cm size class range. Absence of young fish and large older samples limited the production of reasonable	Kishore, R. and Chin, X. 2001. "Age and Growth Studies at The CFRAMP/IMA Regional Age And Growth Laboratory – Progress of Work Done and Future Approaches" presented at the 2000 Caribbean Pelagic and Reef Fisheries Assessment Workshop.

Species	Country	Asymptotic Length L_∞(cm)	Growth Constant K (year^{-1})	t_o (years)	Sample Size (n)	Limitations/Comments	Status Reports/Presentations
						growth estimates. Breaks in sampling prevented marginal increment analysis (MIA) Absence of sex data which allows for comparison of growth parameters between sexes	Ramsundar, H. 2007. Age and Growth Studies of *Acanthurus chirurgus* from Montserrat –report submitted for review
Balistes vetula	Montserrat	75.0 (TL)	0.07	-4.437	207	Sectioned dorsal spine used for age estimates Small data set Few samples at the extreme range of the growth curve (young and old) – affected the growth curve and growth parameters	Ramsundar, H. and Richardson-Drakes, A. 2003. *Age and Growth Studies of Balistes* vetula from Montserrat" – report submitted for review
Cephalophalis fulva	Dominica	46.5 (TL)	0.15	-2.409	24	Sectioned sagittae used for age estimates Small data set Narrow size range Few samples at the extreme range of the growth curve (young and old)	Chin, X. and Richardson-Drakes, A. 2004. Age and growth determination of the coney, *Cephalopholis fulva* and grasby, *C. cruentata* from Dominica. Document Prepared for The CARICOM Fisheries Resources and Assessment Program (CFRAMP). Final Report
Epinephelus guttatus	Grenada	47.25 (TL)	0.133	-3.972	43	Sectioned sagittae used for age estimates	Chin, X. and Richardson-Drakes, A. 2004. Age and growth determination of the red hind *Epinephelus guttatus* from

Species	Country	Asymptotic Length L_∞(cm)	Growth Constant K (year^{-1})	t_o (years)	Sample Size (n)	Limitations/Comments	Status Reports/Presentations
						Small data set Few samples at the extreme range of the growth curve (young and old) Sampled for only three months – MIA not possible	Grenada. Document Prepared for The CARICOM Fisheries Resources and Assessment Program (CFRAMP). Final Report
Holocentrus adscensionis	Dominica	23.0191(TL)	0.547	-0.9247	98	Sectioned sagittae used for age estimates Narrow size range – 101 of the 106 samples received were in the 16-25 cm size range The absence of fish from both ends of the age range has resulted in a low L_∞ and a high t_0 value MIA was inconclusive due to periodic breaks in data collection and small sample size	Solomon, F. and Ramsundar, H. 2007. Age and growth determination of *Holocentrus adscensionis* and *H. rufus* from Dominica. Report submitted for review.
Holocentrus rufus	Dominica	20.752 (TL)	0.1343	-10.0	153	Sectioned sagittae used for age estimates Narrow size range – 155 of 166 samples received were in the 16-20-size range The absence of fish from both ends of the age range resulted in a low L_∞ and a high t_0 value	Solomon, F. and Ramsundar, H. 2007. Age and growth determination of *Holocentrus adscensionis* and *H. rufus* from Dominica. Report submitted for review.

Species	Country	Asymptotic Length L_∞(cm)	Growth Constant K (year^{-1})	t_o (years)	Sample Size (n)	Limitations/Comments	Status Reports/Presentations
						MIA was inconclusive due to periodic breaks in data collection and small sample size	
Lutjanus synagris	Belize	26.5 (TL)	0.13	-10.0	88	Sectioned sagittae used for age estimates Small data set Narrow size range – bulk of samples between 16-30cm Sample period less than one year (6 months); periodic breaks in sampling. MIA not possible Small sample size and narrow size range has resulted in a very low L_∞ and associated high t_o.	Kishore, R. 2005. Age and growth determination of the Lane Snapper, *Lutjanus synagris* from Belize and Jamaica – Final report
Lutjanus vivanus	Dominica	58.5 (TL)	0.133	-0.342	56	Sectioned sagittae used for age estimates Small data set Small/limited size range	Richardson-Drakes, A., Kishore, R. and Guiste, H. 1997. Preliminary Age Determination of Silk Snapper *Lutjanus vivanus* from Dominica, West Indies. Presented at the IMA 5th Research Symposium. Oral presentation
Scomberomorus cavalla	Trinidad	197.1 (FL) (female) 199.5 (FL) (male)	0.098 0.086	-2.33 -2.86	129 40	Sectioned sagittae used for age estimates Growth parameters can be considered tentative because poor agreement between	Chin, X. 2003. Preliminary age growth studies of the Kingfish, *Scomberomorus cavalla* from Trinidad". Presented at the IMA 10th Annual Research Symposium, 2003. Poster presentation

Species	Country	Asymptotic Length L_{∞}(cm)	Growth Constant K ($year^{-1}$)	t_o (years)	Sample Size (n)	Limitations/Comments	Status Reports/Presentations
						primary and secondary readers	
Caranx hippos	Trinidad	104.4 (females) 70.9 (males)	0.103 0.188	-1.673 -1.091	115 120	Sectioned and whole sagittae used for age estimates. Few samples at the upper range of the growth curve (old) MIA was inconclusive due to periodic breaks in data collection and small sample size in some months	Kishore, R. 2003. Age and growth studies of the crevalle jack, *Caranx hippos* from Trinidad using Hard-parts. Presented at the IMA 10th Annual Research Symposium, 2003. Poster presentation. Kishore 2006. Age and growth studies of Caranx hippos (crevalle jack) from Trinidad using hard-parts and selected aspects of age and growth studies of *Acanthocybium solandri* (wahoo) and *Scomberomorus brasiliensis* (carite). Presented at (CRFM) Second Annual Science meeting, March 2006 Kishore, R. and Solomon, F. 2005. Age and growth studies of *Caranx hippos* from Trinidad using hard-parts. Proceedings of the 56th annual conference of the Gulf and Caribbean Fisheries Institute Tortola, BVI. Pg 227-240. Report submitted in 2004 and comments from reviewer received in 2006 were completed. Some additional statistical analysis on the growth curves to be completed.

Appendix 5 – Evaluation Summaries for Methods Investigated during 2006-07

Method	**Data requirements**	**Mgmt advice produced**	**Mgmt measures**	**Level of skills required**	**Costs and risks/ benefits / Dependence on prior beliefs**	**Type of stock / fishery**	**Fisheries/ stocks to which method has been applied**
Hoenig-Gedamke Survival Estimator (Hoenig, J.M. and T. Gedamke. 2007)	Catch rate for two size groups (recruits and post recruits) for at least two years	Total mortality rates	Effort control	Low	Rapid, inexpensive, requires identifying two age groups	Fish stocks	*Panulirus argus, Cynoscion virescens, Microps nebris, Macrodon ancylodon*
Catch only biomass dynamics	Total catch	MSY-Target and limit controls	Quotas and effort control	High	Low costs, dependence on prior information	All with total catch data	To be tested on dolphinfish inter sessionally
Bayesian priors	Any biological information on the stock	Not applicable	Not applicable	High-development Low-application	Low	Any	Queen Conch fishery of St. Lucia
ERAEF	Possible with minimal data on catch and effort. Data and/or understanding of the “fisheries” ecosystem are necessary.	Advice on species/habitat/community units that are at high risk. Advice on controls that reduce the susceptibility of these units	Closed areas, gear controls, closed seasons and other time restrictions, effort reductions.	Relatively minimal quantitative skills, but good understanding of fishery resources and the “fisheries” ecosystem is necessary.	Precautionary in the absence of data; Stakeholder cooperation and inputs essential; Scoring is subjective; Improves overall understanding of “fisheries” ecosystem and impacting hazards; Allows prioritization in cases of limited resources and complex systems; Can be used to demonstrate “no harm” by fisheries	Any	Test in progress for Spiny Lobster fishery in St. Vincent and the Grenadines