FAO Fisheries and Aquaculture Report No. 929 SLC/R929 (En)

ISSN 2070-6987

WESTERN CENTRAL ATLANTIC FISHERY COMMISSION

Report of the

THIRD MEETING OF THE WECAFC AD HOC FLYINGFISH WORKING GROUP OF THE EASTERN CARIBBEAN

Mount Irvine, Tobago, 21–25 July 2008

Copies of FAO publications can be requested from:
Sales and Marketing Group
Office of Knowledge Exchange, Research and Extension
Food and Agriculture Organization
of the United Nations
E-mail: publications-sales@fao.org
Fax: +39 06 57053360
Web site: www.fao.org/icatalog/inter-e.htm

WESTERN CENTRAL ATLANTIC FISHERY COMMISSION

Report of the

THIRD MEETING OF THE WECAFC AD HOC FLYINGFISH WORKING GROUP OF THE EASTERN CARIBBEAN

Mount Irvine, Tobago, 21–25 July 2008

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2010

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views of FAO.

ISBN 978-92-5-106570-9

All rights reserved. FAO encourages reproduction and dissemination of material in this information product. Non-commercial uses will be authorized free of charge. Reproduction for resale or other commercial purposes, including educational purposes, may incur fees. Applications for permission to reproduce or disseminate FAO copyright materials and all other queries on rights and licences, should be addressed by e-mail to:

copyright@fao.org

or to the

Chief, Publishing Policy and Support Branch
Office of Knowledge Exchange, Research and Extension
FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy

© **FAO 2010**

PREPARATION OF THIS DOCUMENT

This document was prepared by the Food and Agriculture Organization of the United Nations (FAO), which organized the Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. It provides full details of the working group's deliberations and results of the flyingfish stock assessment undertaken at the meeting. It also includes a full report of the technical details of the assessment and national reports detailing the analyses and preparation of data used in the assessment, and the revised Draft Subregional Fisheries Management Plan for the Eastern Caribbean Flyingfish, incorporating changes suggested at the meeting.

The work was accomplished under the guidance and supervision of the Western Central Atlantic Fishery Commission (WECAFC) and the Aquaculture Service (FIRA) of the FAO Fisheries and Aquaculture Department.

FAO Western Central Atlantic Fishery Commission.
Report of the Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. Mount Irvine, Tobago, 21–25 July 2008.
FAO Fisheries and Aquaculture Report. No. 929. Rome, FAO. 2010. 88p.

ABSTRACT

Part I of this report provides a summary of the proceedings of the Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. Part II gives a management summary and full report of the flyingfish stock assessment undertaken at the meeting, as prepared by the FAO fisheries consultant with contributions, review and approval by the Ad Hoc Flyingfish Working Group. Part III presents national reports detailing the analyses and preparation of national data sets for use in the regional flyingfish stock assessment. Part IV provides the Draft Subregional Fisheries Management Plan for Flyingfish in the Eastern Caribbean amended as agreed at the meeting.

The key results of the stock assessment conducted at the meeting are that the regional flyingfish stock is not currently overfished and that overfishing has not occurred in the history of the flyingfish fishery. It was agreed by the working group that there is no immediate action required by management to conserve the stock, unless there is a significant increase in regional flyingfish catches. It was further agreed that a catch trigger point of 5 000 tonnes should be established when action would be taken to ensure the stock does not become overfished. Among the agreed actions that should be taken if catches rise to or above the trigger point, is a freeze on further fishery development until a full scientific reassessment of the stock has been completed.

The most significant uncertainty in the current assessment stems from the poor data available on catches and effort. It was agreed that improved data collection and monitoring is essential to ensure sustainable use of this and other fishery resources into the future, and that achieving this improvement should be a priority focus for all members with a flyingfish fishery. It was further agreed that the working group should maintain the electronic database that was assembled at the meeting, ensuring that it always represents the most up-to-date best estimate of flyingfish catch and effort in the subregion to support future reassessments.

The Draft Subregional Fisheries Management Plan for Flyingfish in the Eastern Caribbean, prepared intersessionally after the second meeting, was fully reviewed at this meeting and amendments suggested in order to finalize the first draft of the fisheries management plan for presentation to the eastern Caribbean governments. The amended draft is provided here.

CONTENTS

	Page
Preparation of this document	iii
Abstract	iv
PART I: MEETING REPORT	1
Background and objectives	1
Opening of the meeting	2
Election of Chairperson and adoption of agenda	2
Review of information	2
The stock assessment process	3
Stock assessment results	5
Review of draft management plan	6
Intersessional work plan	7
References	7
Appendix A: Agenda	8
Appendix B: List of documents	10
PART II: MANAGEMENT SUMMARY AND STOCK ASSESSMENT REPORT FOR FLYINGFISH IN THE EASTERN CARIBBEAN	11
Management summary report	12
Technical stock assessment report	15
Technical model description	24
References	28
PART III: NATIONAL REPORTS	31
National report of Barbados: description of data used	31
National report of Saint Lucia	33
National report of Trinidad and Tobago	37
PART IV: DRAFT SUBREGIONAL FISHERIES MANAGEMENT PLAN FOR FLYINGFISH IN THE EASTERN CARIBBEAN	53
Preface	55
Guiding principles	56
Vision of the future	56
Legal context	57
Geography of the region	58
Biology and ecology of flyingfish	64
Management unit	68
Fishery characteristics	68
Status of the fisheries	76
Management objectives and indicators	78
Controls	79
Implementation plan	82
References	84

PART I: MEETING REPORT

BACKGROUND AND OBJECTIVES

1. The WECAFC (Western Central Atlantic Fishery Commission) Ad Hoc Flyingfish Working Group of the Eastern Caribbean was established in accordance with the recommendations of the ninth session of WECAFC and of the sixth session of the Committee for the Development and Management of Fisheries in the Lesser Antilles, held in Saint Lucia from 27 to 30 September 1999. The recommendations stated, *inter alia*, that "*in order to achieve effective regional or subregional management of their shared fisheries resources, member states and the WECAFC should establish ongoing ad hoc working groups following the pattern of e.g. ICCAT and ICES".* The formation of the working group sought to facilitate implementation of the objectives and articles of the FAO Code of Conduct for Responsible Fisheries (FAO, 1995).

2. The ninth session of WECAFC recommended that the scope of the working group be the flyingfish fisheries of the WECAFC Region and that the group take a multidisciplinary approach and "pay due attention to the linkages between flyingfish fisheries and related or interacting species and fisheries (e.g. larger oceanic pelagic species and oceanic surface trolling and subsurface longlining fisheries)".[1]

3. The terms of reference established by the ninth session required that the working group interacts closely with the WECAFC Secretariat. The working group was mandated to serve in an advisory capacity to guide and facilitate the sustainable development of flyingfish fisheries, through the formulation and review of a regional fisheries management plan (FMP) for each flyingfish stock.

4. Since its inception, the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean has met twice. The first meeting took place in Bridgetown, Barbados, from 22 to 24 September 1999. At this meeting, the working group was mandated to execute two intersessional activities: (i) improvement of national catch and effort data sets; and (ii) execution of national social and economic surveys. At the second meeting held in Barbados in 2001, a preliminary analysis of the eastern Caribbean flyingfish fishery was done and recommendations for improving future stock analyses were put forward. This meeting recommended a third meeting to further the subregional initiative towards shared management of the flyingfish stock under the FAO Code of Conduct for Responsible Fisheries.

5. The Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean was held in Mount Irvine, Tobago, from 21 to 25 July 2008. The meeting was jointly organized by the Tobago House of Assembly and the Food and Agriculture Organization of the United Nations (FAO), with funding from FAO, as well as the Ministry of Agriculture, Lands and Marine Resources in Trinidad.

6. The main objectives of the third meeting were to:

(a) assemble the best available flyingfish data sets from the member countries of the WECAFC Ad Hoc Flyingfish Working Group for analysis and assessment of the status of the subregional flyingfish resource;

(b) review the Draft Subregional Fisheries Management Plan for Flyingfish in the Eastern Caribbean; and

[1] Report of the ninth session of the Western Central Atlantic Fishery Commission and of the sixth session of the Committee for the Development and Management of Fisheries in the Lesser Antilles, Castries, Saint Lucia, 27–30 September 2009 (Appendix E).

(c) provide scientific advice to the member countries of the working group based on the stock assessment and review of the management plan.

OPENING OF THE MEETING

7. The meeting was opened by Mr Kenneth Caesar, Director of the Department of Marine Resources and Fisheries of the Tobago House of Assembly on Monday, 21 July. Mr Caesar welcomed the participants to the meeting and highlighted its importance in assessing the regional stock of flyingfish.

8. Participants from Barbados, Grenada, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago attended the meeting. Also present were FAO Fisheries Consultant, Dr Paul Medley, invited to assist with the technical aspects of the stock assessment, and representatives from the FAO Subregional Office (Barbados) and the Centre for Resource Management and Environmental Studies (CERMES), University of the West Indies. The list of participants is attached as Appendix II.

9. Mr Randolph Walters, Fishery Officer of the FAO Subregional Office for the Caribbean (SLC) delivered an address on behalf of the Director-General of FAO, Mr Jacques Diouf. Mr Walters thanked the Government of Trinidad and Tobago for the funding provided and its generosity in hosting the meeting. He provided some background information on achievements of the two previous meetings and wished the participants a successful meeting.

10. The Honourable Hilton Sandy, Secretary of Agriculture of the Division of Agriculture, Marine Affairs, Marketing and the Environment of the Tobago House of Assembly, delivered the feature address. Mr Sandy emphasized the importance of flyingfish as well as other marine resources to Trinidad and Tobago and noted that the Tobago House of Assembly has responsibility for the fisheries off Tobago. Mr Sandy made mention of upcoming negotiations for a fishing access agreement between Trinidad and Tobago and Barbados, and noted that the terms and conditions of this agreement should not be at the disadvantage of fishers from Tobago. He also highlighted the importance of fisheries to Tobago as a food source and a developmental opportunity for addressing increasing food prices and national food security.

ELECTION OF CHAIRPERSON AND ADOPTION OF AGENDA

11. The meeting was chaired jointly by Mr Kenneth Caesar of the Department of Marine Resources and Fisheries of the Tobago House of Assembly and Dr Arthur Potts of the Institute of Marine Affairs, University of Trinidad and Tobago.

12. The agenda for the meeting, Appendix I, was reviewed and it was agreed that presentation of the national reports would be excluded from the agenda since some participants had not yet completed them. It was further agreed that these reports would be submitted after the meeting and included in the meeting report. The revised agenda was accepted.

REVIEW OF INFORMATION

National reports

13. National reports providing an overview and update on the flyingfish fisheries were submitted by Barbados, Saint Lucia, and Trinidad and Tobago. These reports are provided in Part III of this document.

Assessment methods

14. Dr Medley, Fisheries Consultant, presented the available options for assessment of the regional flyingfish stock. He noted previous assessments conducted by Mahon (1989), and the extensive research conducted by the Eastern Caribbean Flyingfish Project and staff and graduates of the University of the West Indies that has now been assembled, reviewed and published under one cover (Oxenford *et al.,* 2007). He outlined the difficulties in assessing the species, due primarily to their biology (short-lived, open-water species), the nature of the fishery (targeting spawning adults) and the susceptibility of the species to environmental variations.

15. The consultant proposed the use of a Stock Recruitment Model and associated risk assessment approach with decision rules to facilitate management decision-making. The working group agreed that this would be an appropriate way to proceed with the assessment of the eastern Caribbean flyingfish stock.

National data sets

16. Country representatives gave a brief overview of their respective country data sets, including the time period, data source and quality.

THE STOCK ASSESSMENT PROCESS

17. The working group, together with the fishery consultant, spent a significant portion of the meeting understanding and preparing national data sets and interpolating data where no landings figures were available, or available figures were clearly spurious, in order to complete time-series estimates of flyingfish landings across the eastern Caribbean flyingfish stock range states. Commercial catches of flyingfish were available from Barbados (1950–2007); Tobago (1955–2008); Grenada (1978–2007); and Saint Lucia (1981–2008). Since commercial catches in Saint Vincent and the Grenadines are known to be small, an estimate of one tonne per year was assumed for 1978–2007.

18. After an initial examination of these catch data sets, the meeting agreed that the available data were undoubtedly underestimating actual catches of flyingfish from the eastern Caribbean stock. In particular, it was noted that flyingfish harvested for use as bait was poorly recorded, but needed to be taken into consideration. It was agreed that a flat figure would be used as a proxy across all countries (except Grenada) in all years from 1980–2007. Given that Grenada's flyingfish fishery is now largely a bait fishery and believed to be quite significant, estimates were developed by the working group under the guidance of the Grenada representative for the years 1982–2007, based on: the number of longline vessels known to be operating in Grenada in certain years (1982, 1988, 1993, 1997, 1999 [see Mohammed and Rennie, 2003] and 2007 [Grenada Fisheries Division]); and an assumed quantity of bait utilized each year derived from the average number of hooks deployed per vessel, and an assumed proportion of total bait attributed to flyingfish. These data interpolations are recorded in a Microsoft Excel worksheet associated with the model.

19. For countries with few data, the working group assembled estimates from a number of sources. For Martinique, the landings estimate obtained by the Eastern Caribbean Flyingfish Project (ECFFP) for 1988 was applied to all subsequent years. For Dominica, the landings estimate obtained by the ECFFP was used for 1988–1995; data provided by the Dominica Fisheries Division at the Second Caribbean Regional Fisheries Mechanism (CRFM) Scientific Meeting were used to guide estimates from 1996-2000 and landing estimates obtained by the FAO Lesser Antilles Pelagic Ecosystem project were used for the period 2001–2007.

20. The final estimated total catch time series for flyingfish in the eastern Caribbean, used in developing the model, is shown in Figure 1 and is available with full details of data source and interpolations recorded in the Microsoft Excel spreadsheet associated with the model.

21. Time was also spent by participants on reviewing available biological information for flyingfish (*Hirundichthys affinis*) to select the most appropriate biological parameters for the model.

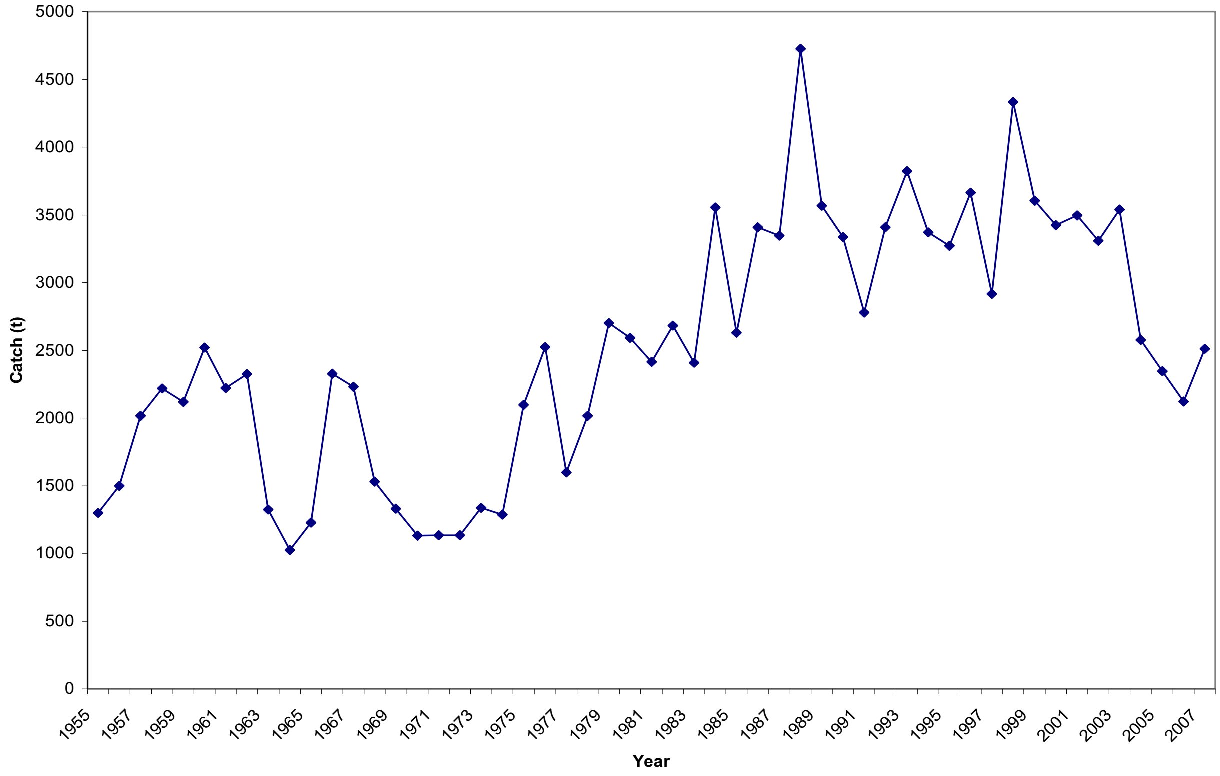


Figure 1. Time series of estimated total flyingfish catches from the eastern Caribbean stock, used to inform the assessment model. Data represent recorded or estimated commercial landings for Barbados (1950–2007), Tobago (1955–2007), Grenada (1978–2007) including flyingfish caught for bait (1982–2007), Saint Lucia (1981–2007), St Vincent and the Grenadines (1978–2007), Dominica (1988–2007) and Martinique (1988–2007). A crude estimate of flyingfish caught and used directly for bait in all islands apart from Grenada from 1980–2007 is also included.

22. The assessment model was then developed by the consultant using the "best available data" prepared by the working group (programmed in "visual basic", associated with the Microsoft Excel spreadsheet data and tested on sample data sets to assess model performance) and the outputs of each model trial explained and discussed further by the working group until a best-fit model was developed.

23. The best-fit model was then run to examine stock behaviour under different levels of harvesting, to assist in the selection of appropriate limit and target reference points for management of the flyingfish resource.

24. The trends in standardized flyingfish catch per unit effort (CPUE) were also examined by the working group under the guidance of the consultant. For this exercise, CPUE data from Barbados, Tobago and Saint Lucia for the period 1998–2007 were used and data were standardized against the January catches of the day-boat fleet in Barbados each year (Figure 2).

25. Subsequent discussion focused on whether the observed trends could be used as a reliable index of the recent trends in eastern Caribbean flyingfish abundance, given the influence of market demand on landings, particularly in the case of the Tobago fishery. However, it was agreed that Tobago data should still be included, since their omission made little difference to the observed regional trend.

26. Despite reservations with the use of the CPUE data as an indicator of flyingfish abundance, no alternative indicator could be identified and so a decision was taken by the working group to use it as the best available data.

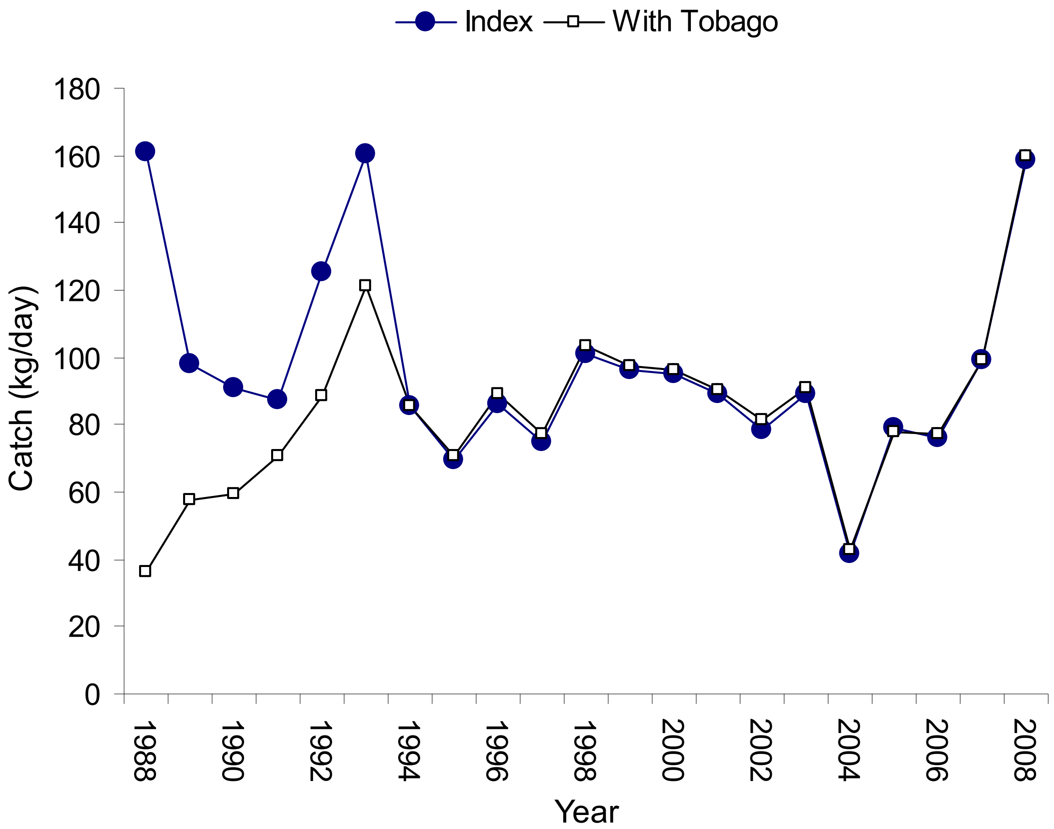


Figure 2. Standardized index of abundance for eastern Caribbean flyingfish representing catch per unit effort data for Barbados, Saint Lucia and Tobago.

STOCK ASSESSMENT RESULTS

State of the stock

27. The results of the preliminary stock recruitment model indicated that the eastern Caribbean flyingfish stock is not experiencing overfishing.

28. It was agreed, however, that the assessment could not be used to determine whether or not "local depletion" may be occurring, as the data are not available at the level of detail required to examine this.

29. It was determined that catch rates have remained fairly stable even with increased overall catches. Further, given the potential stock area, and estimates of a relatively large stock size from tagging data and from survey data, it is unlikely that catches have ever exceeded the maximum

sustainable yield (MSY) from this stock. As such, there is no evidence that this stock has ever been overfished.

Management advice

30. It was agreed that there is no immediate management action required to conserve the eastern Caribbean flyingfish stock.

31. It was noted, however, that the most significant uncertainty in the assessment stems from the poor regional data available on catches and effort and that improvements in efforts to collect these data are essential.

32. Management target and limit points were considered with reference to the assessment. A reference point based on MSY was considered too uncertain at this time. Instead it was decided that a "catch trigger point" should be established based on current total catches and the stock assessment model.

33. The maximum recorded catch to date is 4 700 tonnes, and a catch trigger point of 5 000 tonnes was considered to be an appropriate choice given that the assessment indicates that any fisheries development exceeding 5 000 tonnes would have unpredictable consequences. Regional catches at or above the trigger point would therefore require management action to safeguard the stock from overfishing.

34. The working group discussed a range of actions that could be taken if catches were to rise to, or above, the trigger point. A freeze on further fishery development was considered to be the most appropriate and pragmatic at this time, until such time as a full scientific reassessment of the stock is undertaken. Such a reassessment may lead to further regional controls.

Output

35. It was agreed that the consultant would write a Management Summary Report for flyingfish and a detailed Technical Stock Assessment Report for the meeting, which would be circulated via e-mail to participants for review and finalization by the group.

36. The finalized Management Summary Report and detailed Technical Stock Assessment Report are included here in Part II.

REVIEW OF DRAFT MANAGEMENT PLAN

37. The working group reviewed the draft regional management plan for the flyingfish resources of the eastern Caribbean prepared intersessionally (see Oxenford, 2002) and suggested a number of amendments as detailed below.

38. It was agreed that information contained in all figures and tables should be updated. In addition, the papers published in the proceedings of the 1996 Small Coastal Pelagics and Flyingfish Sub-project Specification Workshop of the CARICOM Fisheries Resource Assessment and Management Programme (CFRAMP) should be consulted, and relevant information included in the management plan.

39. It was further agreed that results of the current stock-recruitment analyses would be included under the section headed "Target and Limit Reference Points" and references to previous yield-per-recruit and surplus production models should be included in a footnote, as these methods were deemed inappropriate for assessing the status of flyingfish resources.

40. The working group agreed that the Management Summary Report, to be written by the consultant and reviewed by the working group, should be included in the first section of the amended FMP.

41. The list of future research to be conducted was revised, with the highest priority to be placed on the acquisition of accurate fisheries data (total catch and catch per unit effort).

42. It was further recognized that acquisition of information on abundance and spawning behaviour of the species should receive high priority, as well as refining the risk assessment model to examine the effects of oceanographic and biotic variables on the stock recruitment relationship.

43. Another area of high priority is to explore the impacts of management options related to time and area closure, on stock rebuilding.

44. The amended Draft Subregional Fisheries Management Plan for Flyingfish in the Eastern Caribbean is given in Part IV.

INTERSESSIONAL WORK PLAN

45. The Draft Subregional Fisheries Management Plan for Flyingfish in the Eastern Caribbean will be further updated with country-specific information. Country representatives agreed to send updates of national information not readily available on the Internet, in particular, information on:

- Social and economic indicators of the importance of flyingfish to the eastern Caribbean (FMP, Table 4).
- Policy and legislation specific to flyingfish (to be included in a Table).
- Credit and monetary incentives for fishery development (FMP, Table 5).

46. All member countries will improve their flyingfish catch and effort data.

47. It was agreed that the next meeting should be no later than one year from the current meeting, pending the completion of intersessional activities.

REFERENCES

FAO. 1995. Code of Conduct for Responsible Fisheries. Rome, FAO. 41pp.

Mahon, R. 1989. Developing a management strategy for the flyingfish fishery of the eastern Caribbean. Proceedings of the Gulf and Caribbean Fisheries Institute 39: 389-402

Mohammed, E. & Rennie, J. 2003. Grenada and the Grenadines: Reconstructed fisheries catch and fisheries effort, 1942–2001. Fisheries Centre Research Reports 11:67-93

Oxenford, H.A. 2002. Draft Subregional Fisheries Management Plan for Flyingfish in the Eastern Caribbean. For WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. FAO-SLAC/Activity – RA233S1001010, 34pp.

Oxenford, H.A., Mahon, R. & Hunte, W. (eds). 2007. Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados. 268pp.

APPENDIX A

Agenda

Monday, 21July 2008

08.30–09.15 hrs	Registration of participants
09.15–10.00 hrs	Formal opening of meeting
10.00–10.30 hrs	Review and adoption of agenda.
10.30–10.45 hrs	*BREAK*
10.45–12.30 hrs	National reports – inclusive of discussions
12.30–13.30 hrs	*LUNCH*
13.30–15:15 hrs	National reports, continued
15.15–15.30 hrs	*BREAK*
15.30–17.00 hrs	Participants to begin manipulating/cleaning national flyingfish data, where necessary, using the procedures, guidance and the analytical/assessment models supplied

Tuesday, 22 July 2008

09.00–10.30 hrs	Participants to continue manipulating/cleaning national flyingfish data, where necessary, using the procedures and the analytical/assessment models supplied
10.30–10.45 hrs	*BREAK*
10.45–12.30 hrs	Participants to continue to manipulate their data sets
12.30 –13.30 hrs	*LUNCH*
13.30–15.30 hrs	Participants to continue manipulating their data
15.30–15.45 hrs	*BREAK*
15.45–17.00 hrs	Participants to begin preparation of short reports on the results of their work (highlighting issues such as: areas for improving data sets and identifying gaps)

Wednesday, 23 July 2008

09.00–09.30 hrs	Finalization of individual country reports for presentation and group discussion
09.30–10.30 hrs	Participants to present a short report of their work to the group
10.30–10.45 hrs	*BREAK*
10.45–12.30 hrs	Participants to begin synthesizing national data sets in preparation for analysis and a joint assessment of the status of the eastern Caribbean flyingfish stock
12.30–13.30 hrs	*LUNCH*
13.30–15.00 hrs	Participants to continue synthesizing national data sets in preparation for analysis and a joint assessment of the status of the eastern Caribbean flyingfish stock
15.15 –15.30 hrs	Brief discussions of the available stock assessment models and the option(s) most suitable for use in the current exercise
15.30 –15.45 hrs	*BREAK*
15.45–17.00 hrs	Participants to begin the assessment using the models and the analytical/assessment methodologies and guidance provided

Thursday, 24 July 2008

9.00–10.30 hrs	Continuation of the assessment activities

10.30–10.45 hrs	*BREAK*
10.45–12.30 hrs	Finalization of assessment activities and preparation of the report of the results
12.30–13.30 hrs	*LUNCH*
13.30–15.00 hrs	Presentation and discussion of the results of the stock assessment results
15.00–15.30 hrs	Drafting of the stock assessment report
15.30–17.00 hrs	Drafting of recommendations on future management actions and needs – including future research needs
Friday, 25 July 2008	
09.00–10.30 hrs	Presentation of the draft stock assessment report and the related recommendations for future management actions
10.30–10.45 hrs	*BREAK*
10.45–12.30 hrs	Discussion of the results of the stock assessment of the flyingfish, and suggestions for future actions and adjustments both nationally and subregionally to ensure sustainable utilization of the flyingfish resource
12.30–13.30 hrs	*LUNCH*
13.30–15.15 hrs	Introduction and discussion of the Draft Flyingfish Management Plan (prepared intersessionally by the secretariat)
15.15 –15.30 hrs	*BREAK*
15.30–16.30 hrs	Discussion of and suggestions for adjustments to the Draft Flyingfish Management Plan that are relevant to future assessment of the flyingfish resource
16.30–17.00 hrs	Suggestions for Intersessional actions at the national level to improve cooperation and sustainable management of the flyingfish
	Any other matters, proposed time and venue of next meeting
	Conclusion of the meeting

APPENDIX B

List of participants

BARBADOS
Ms Joyce Leslie
Deputy Chief Fisheries Officer
E-mail: dcfo@agriculture.gov.bb

Mr Christopher Parker
Fisheries Officer
E-mail: fishbarbados.fb@caribsurf.com

Fisheries Division
Princess Alice Highway
Bridgetown, Barbados
Tel.: (246) 426-3745
Fax: (246) 436-9068
E-mail: fishbarbados.fb@caribsurf.com

GRENADA
Mr Paul Phillip
Fisheries Officer
Fisheries Division
Ministry of Agriculture, Forestry, Lands, Fisheries, Public Utilities and Energy
Ministerial Complex, Botanical Gardens
St George's, Grenada
Tel.: (473) 440-3814/3831
Fax: (473) 440-4191
E-mail: fisheries@gov.gd

SAINT LUCIA
Ms Patricia Hubert-Medar
Fisheries Assistant
Department of Fisheries
Ministry of Agriculture, Forestry and Fisheries
Waterfront Buildings, Castries
Tel.: (758) 468-4134/5
Fax: (758) 452-3858
E-mail: deptfish@slumaffe.org

SAINT VINCENT AND THE GRENADINES
Mr Raymond Ryan
Chief Fisheries Officer

Mr Kris Isaacs
Fisheries Assistant

Fisheries Division
Ministry of Agriculture and Fisheries
Tel.: (784) 456-1178/2738
Fax: (784) 457-2112
E-mail: fishdiv@caribsurf.com

TRINIDAD AND TOBAGO
Dr Arthur C. Potts
University of Trinidad and Tobago
Hilltop Lane, Chaguaramus
Trinidad and Tobago
Tel.: (868) 634-4291
E-mail: artpotts@hotmail.com

Ms Elizabeth Mohammed
Director of Fisheries (ag)
Fisheries Division
Ministry of Agriculture, Lands and Marine Affairs, St Clair Circle, St Clair, Port of Spain
Tel./Fax: (868) 639-1382
E-mail: fishmar@tstt.net.tt

Mr Kenneth Caesar
Director of Fisheries
TLH Building Scarborough
Tobago, Trinidad and Tobago
Tel./Fax: (868) 639-1382
E-mail: fishmar@tstt.net.tt

FAO
Mr Randolph Walters
Fishery Officer
Subregional Office for the Caribbean (SLC)
PO Box 631-C, Bridgetown, Barbados
Tel.: (246) 426-7110/11
Fax: (246) 427-6075
E-mail: Randolph.Walters@fao.org

FAO Consultant
Dr Paul Medley
Sunny View, Jack House
Alne, North Yorkshire
YO61 IRT
United Kingdom
Tel.: 01 347 838236
E-mail: paul.medley@virgin.net

CERMES/UWI
Dr Hazel Oxenford
Professor of Marine Ecology and Fisheries
Centre for Resource Management and Environmental Studies (CERMES)
The University of the West Indies
Cave Hill Campus, Barbados
Tel.: (246) 417-4571
E-mail: hazel.oxenford@cavehill.uwi.edu

PART II: MANAGEMENT SUMMARY AND STOCK ASSESSMENT REPORT FOR FLYINGFISH IN THE EASTERN CARIBBEAN

Primary author:

Paul Medley

Fisheries Consultant

Contributing authors:

Kenneth Caesar, Patricia Hubert-Medar, Kris Isaacs, Joyce Leslie, Elizabeth Mohammed, Hazel A. Oxenford, Chris Parker, Paul Phillip, Arthur C. Potts, Raymond Ryan, Randolph Walters

Participants of the Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean

Contents

1. MANAGEMENT SUMMARY REPORT **12**
1.1 State of stock **12**
1.2 Management advice **12**
1.3 Reference points **12**
1.4 Harvest strategy **12**
1.5 Harvest control rule **12**
1.6 Stock assessment **13**
1.7 Data used **15**

2. TECHNICAL STOCK ASSESSMENT REPORT **15**
2.1 Available data **15**
2.2 Stock assessment model **15**
2.3 Probability priors for stock assessment parameters **17**
2.4 Precautionary reference points **20**
2.5 Decision rule **20**
2.6 Projections **21**
2.7 Recommendations **23**

3. TECHNICAL MODEL DESCRIPTION **24**
3.1 Posterior calculation **24**
3.2 Including catches **25**
3.3 Fitting the model **26**

4. REFERENCES **28**

1. MANAGEMENT SUMMARY REPORT

1.1 State of stock

The stock assessment suggests that the stock is not overfished and that overfishing is not occurring.

The catch rates have remained stable overall in the time series as catches have increased. Given the potential stock area, and estimates of a relatively large stock size from tagging and survey estimates, it is likely that the potential yield exceeds total catches taken throughout the history of the fishery.

1.2 Management advice

There is no immediate action required by management to conserve the stock, unless there is a significant increase in catches.

A catch trigger point of 5 000 tonnes should be established when action may be taken to ensure the stock does not become overfished. The trigger point defines when further management action should be undertaken. The maximum recorded catch has been 4 700 tonnes. The assessment indicates that any fisheries development exceeding 5 000 tonnes would have unpredictable consequences.

Among the actions that should be taken if catches rise to, or above, the trigger point, are a freeze on further fishery development until a full scientific reassessment of the stock has been completed. An improved stock assessment may lead to further international fishing controls.

The most significant uncertainty in the current assessment stems from the poor data available on catches and effort. Improved data collection and monitoring is required to ensure sustainable use of this and other fishery resources.

1.3 Reference points

A formal reference point based on maximum sustainable yield (MSY) is too uncertain at this time. It is advised instead that a trigger point be established based on total catch using the current stock assessment to ensure that fishery development is monitored and that expansion is not too rapid.

The stock should not be reduced below B_{MSY}. Current evidence suggests that the stock is well above this limit, but where the limit lies is highly uncertain.

1.4 Harvest strategy

An interim catch limit of 5 000 tonnes is proposed. Sustained catches at, or above, this level are likely to bring about an unacceptable risk of overfishing. Either catches must be maintained below this level, or further research, data collection and stock assessment work is required to enable a new higher limit to be set while still ensuring that the limit is safe.

Further research may allow this limit to be increased. Research recommendations are outlined in the Draft Subregional Fisheries Management Plan in Part IV.

The long-term aim would be to take a fixed proportion of the stock each year based on the MSY. As yet, the estimate of this proportion is too imprecise to suggest any particular value, but it is very likely that the catch taken each year would exceed current catches. As this target catch is approached, further controls would be required to ensure the biomass was not depleted below the MSY point. If it was intended to develop this fishery, much improved data collection would be required to avoid the possibility overfishing.

1.5 Harvest control rule

A detailed harvest control rule has not been tested in the current stock assessment. A target reference point for fishing mortality of 2/3 F_{MSY} has been proposed. Once a reliable MSY estimate is available, this reference point should be established, giving guidance on total allowable catches and fleet capacity.

Further reductions on fishing mortality (i.e. reductions in fishing effort and catches) would be required when biomass is detected to be below the MSY point. Fishing the stock to MSY would require substantial fishery development, which should be accompanied by closer monitoring of the stock.

1.6 Stock assessment

A simple model was used building on a previous application of a stock-recruitment model for a risk assessment (Mahon, 1989). A technical description of the stock assessment is given here in Section 3. The assessment used all available data (catch and fishing effort time series), as well as allowing for environmental effects causing unexpected changes in recruitment. It represents the best assessment to date.

A new Bayesian statistical method is used to fit the model of the stock dynamics to the available data. This method explicitly models the uncertainty, which is therefore well accounted for. It was thought to be necessary to use a Bayesian approach because:

- alternative methods, such as maximum likelihood, would not work well;
- additional information on life history and surveys could be used which otherwise would have to be excluded; and
- scientific advice would incorporate full uncertainty as this is thought to have a dominant effect in this case.

The model and assessment have not been fully tested. No sensitivity analyses were carried out. The model appears to fit the data reasonably well and the population behaves as expected. However, further development of this model is required, including rigorous testing to ensure the management advice is sound.

Table 1. Summary of stock assessment results. R0 and the unexploited biomass are fitted parameters, and the remaining values are indicators of interest. The 90 percent confidence interval for B/B_{MSY} and F/F_{MSY} exclude 1.0, indicating that there is only a very small chance that the stock was being overexploited in 2007.

	0.05	**Median**	**0.95**
R0	1.72	3.40	10.51
Unexploited biomass (tonnes)	10 870	26 351	131 428
Biomass 2007 (tonnes)	10 011	25 919	131 306
MSY (tonnes)	3 312	7 897	36 291
2007 yield (tonnes)		2 512	
B/B_{MSY}	1.97	2.71	4.17
F/F_{MSY}	0.03	0.17	0.50

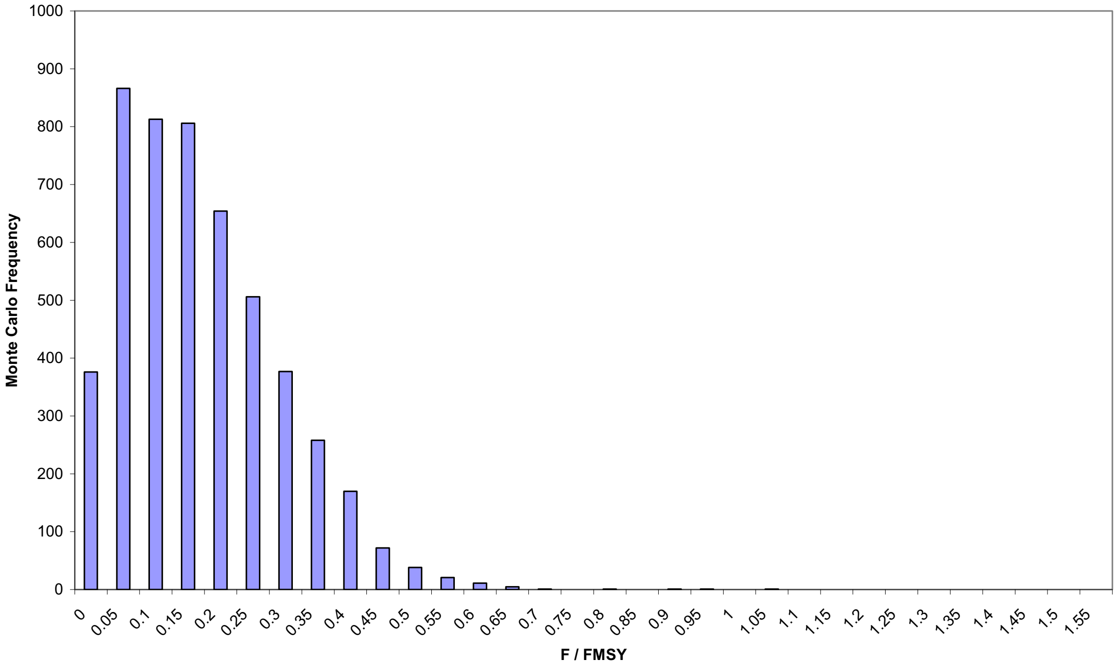


Figure 1. The F/F_{MSY} statistic indicates whether overfishing is occurring. As almost all the probability mass (represented by the Monte Carlo Frequency) is below 1.0, this indicates that the exploitation rate is below that required to obtain the MSY and therefore appears safe. There is no evidence of overfishing on this stock.

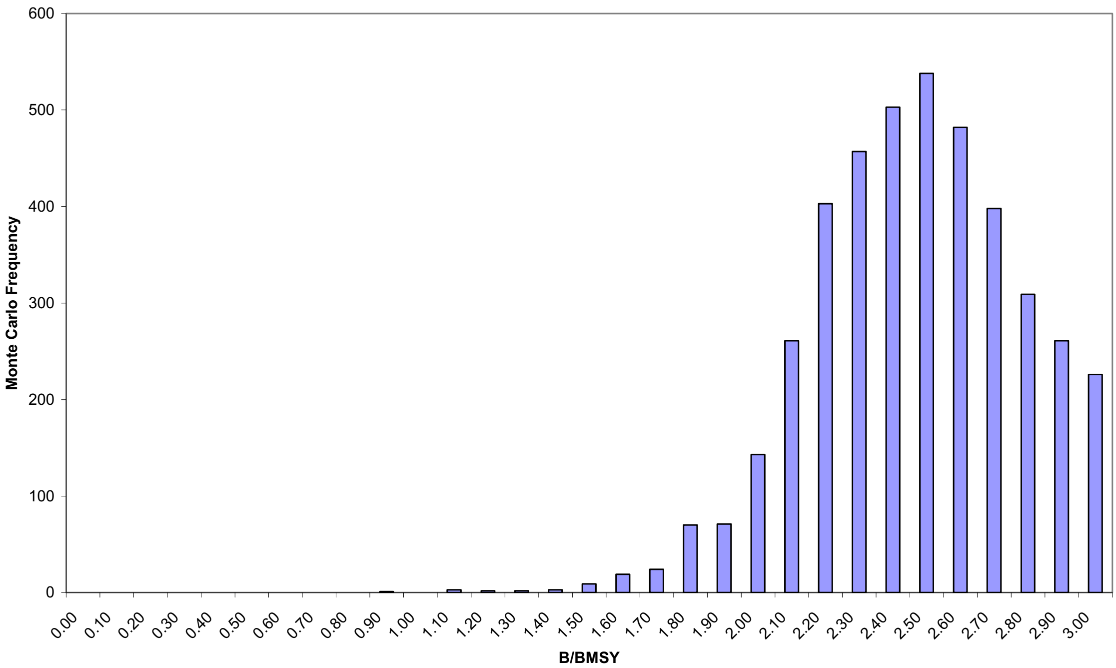


Figure 2. B/B_{MSY} is used to indicate the state of the stock. The fact that almost all the probability mass is above 1.0 shows that the biomass is well above that which would maximize the yield. There is no evidence that the stock is overfished.

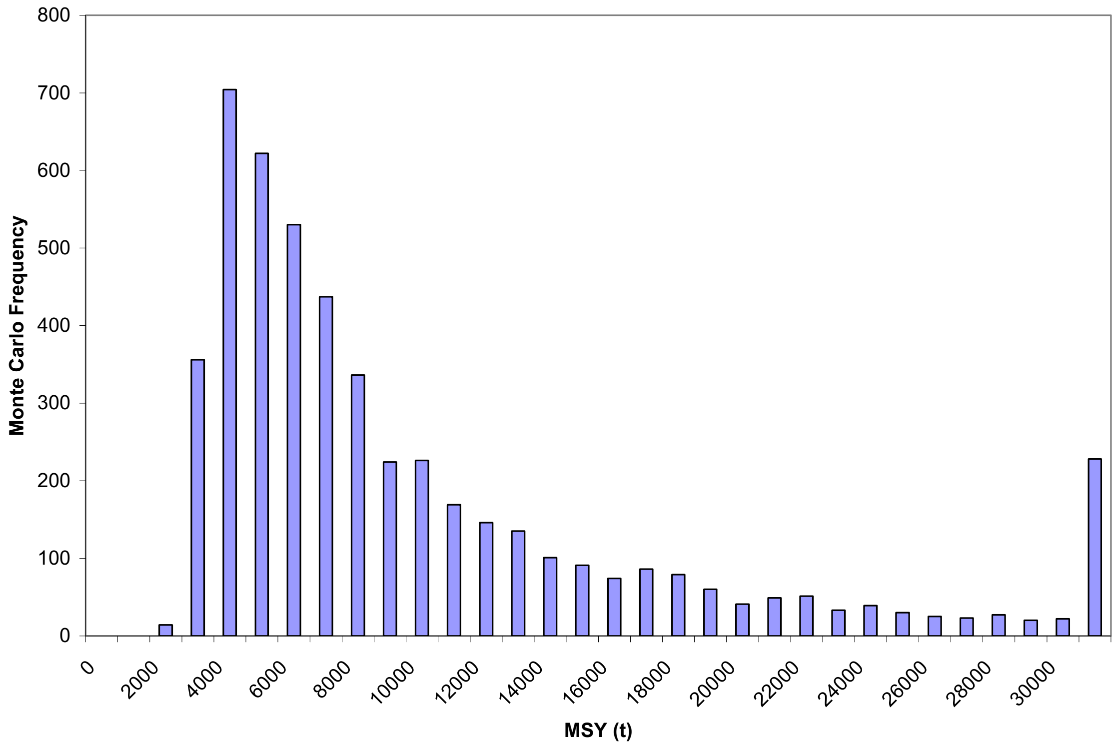


Figure 3. The MSY indicates the general potential yield for this stock. The probability density is heavily skewed with the mode well to the left of the mean. The mode for the posterior is around 4000 tonnes. Sustained catches higher than this become risky.

1.7 Data used

Total catches were compiled from Barbados, Dominica, Grenada, Saint Lucia, Saint Vincent, and Tobago. These catches were considered by the working group to be the best estimates available, but were probably not highly accurate. In particular, catches used for bait are poorly recorded and the working group spent considerable time estimating these. It is likely that bait could be a significant use of this resource.

Catch and effort data were available from Barbados, Tobago and Saint Lucia. These data were combined into a single standardized index of abundance using a generalized linear model. While it is thought that catch per unit effort should be linearly related to stock size, this could not be verified at the meeting.

2. TECHNICAL STOCK ASSESSMENT REPORT

2.1 Available data

Total catches and catch and effort data were obtained from various sources and assembled into a spreadsheet, which includes documentation on the data sources and, where appropriate, how data were derived. The spreadsheet should be maintained as the most up-to-date best estimate of the data. These values should be documented in as great a detail as possible.

2.2 Stock assessment model

The stock assessment model chosen to represent the dynamics was the Beverton and Holt model. As this is an annual species, and the catches and catch per unit effort index refers to the stock when it is actually spawning, it is believed that a simple stock recruitment relationship would capture the species dynamics from year to year. A different model might be developed for within-year dynamics, but data are not sufficient to support this.

In contrast to the Ricker model, which was used by Mahon (1989), the Beverton and Holt model has a flat top, so recruitment does not decline at higher stock sizes. There were two reasons for choosing the Beverton and Holt model over the Ricker model:

1. The flat top of the Beverton and Holt model makes fitting the model simpler. Using the Ricker model would have required more work fitting high population sizes which are unlikely and therefore should have little influence on the result.
2. The requirements for the Ricker model could not be justified based on knowledge of the life history. The Ricker model links the mortality rate to the original spawning stock size, not the current number of eggs, larvae or juveniles. Possible reasons for this include adult cannibalizing eggs or larvae, disease transmission, adults damaging eggs or reducing spawning sites and density dependent growth (rather than mortality) coupled with size dependent predation.

It is possible that the Ricker model is a better description of the process. For example, excessive numbers of eggs could sink floating objects reducing available spawning at higher stock sizes. If evidence for the Ricker model became available, this model should be chosen in preference to the Beverton and Holt model. However, it would not be likely to make much difference to final results as it only affects recruitment at higher stock sizes, although it is possible that the Ricker model could decrease stability, so this should be kept under review.

TABLE 2

Form and parameterization used in the Beverton and Holt stock recruitment model

N_∞	Mean asymptotic size for the stock with no fishing.
R_0	Maximum rate of population increase, when the stock size is very small (no density dependent mortality). $R_0 > 1$
$S_{t+1} = \frac{N_\infty R_0 S_t}{N_\infty + (R_0 - 1)S_t}$	
B_{MSY}	$N_\infty \frac{\sqrt{R_0} - 1}{R_0 - 1}$
MSY	$\frac{N_\infty \sqrt{R_0}\left(\sqrt{R_0} - 1\right)}{(R_0 - 1)}$

Biomass dynamics models, such as the Schaefer or Fox Models, were not used. As this is an annual species with negligible spawning stock surviving more than one year, a model describing biomass growth was thought less appropriate for modelling the entire generation in a single step. It should be noted that the Beverton and Holt model is derived from the logistic differential equation, which forms the basis of the Schaefer biomass dynamics model.

The general oceanographic effects on the flyingfish population size are thought to be significant. Some information was available at the working group meeting on oceanographic variables, including sea surface temperature indices, upwelling indices and hydrometric data from Guyana. No information was available on how these indices might reflect changes in abundance and/or catchability, and there was not time at the meeting in 2008 to consider this issue.

The environmental effect was covered by including process error. Process error models the population dynamics as a stochastic process in discrete time, so that the population model describes a parameter (the mean) of the probability density function of the stock size conditional on the previous stock size. A second parameter, the process error scale parameter, describes how the probability is distributed around the mean. In common with most stock-recruitment models, the error is assumed to be log-normal (Hilborn and Walters, 1992).

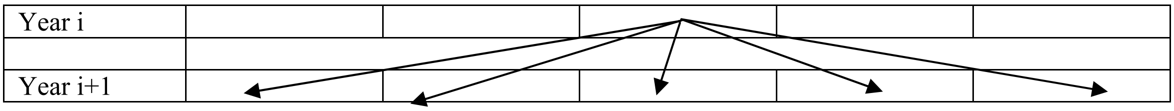


Figure 4. Schematic diagram showing the contributions a particular stock size will make to the next year's population through the stock recruitment relationship. Each category represents the population sizes within a predefined range. The higher the number of categories, the higher the precision of the relationship. As the model is stochastic, each category is occupied by the current stock with a probability and the stock of any category could produce any recruitment placing the next stock in any of categories, but depending on the probability. The larger the stock is, the larger the recruitment is likely to be. The categories define the same likely recruitment from all populations within the category range, and are used to simplify the dynamics. The contribution to the next year's stock, here shown for one category, is combined with the contributions from all the other categories, so all 5*5 permutations are considered.

2.3 Probability priors for stock assessment parameters

2.3.1 Potential rate of increase

The maximum rate of increase (R_0) can be approximated using life history information. Density dependent mortality is not applied, but natural mortality and fecundity need to be accounted for. Females will produce an average number of eggs in their lifetime, of which a proportion, in the absence of density dependent mortality, will produce mature females which contribute to spawning. The average number of females surviving from the eggs of the previous generation is the R_0 parameter for the Beverton and Holt model. Clearly, this value must be greater than 1.0 or the population will go extinct.

It is believed that generally larval and small fish mortality is much higher than adult fish, and this additional mortality should be accounted for. Investigations of this have suggested the way natural mortality changes with length may be approximated by a simple reciprocal relationship (Lorenzen, 1996). This mortality can be modelled using the growth equation:

$$N_t = N_0 \left(\frac{L_0}{L_0 + L_\infty \left(e^{Kt} - 1 \right)} \right)^{\frac{M_1}{L_\infty K}}$$

Where L_0=length at hatching, L_∞=asymptotic length and K=growth rate for the von Bertalanffy growth curve, M_l=natural mortality at unit length, and t = age at maturity. M_l can be estimated from the estimate of adult (M) where $M_l = M_{adult}/L_{adult}$. Once mature, a female will spawn in batches, with approximately 7 000 eggs per batch. We assume one batch is spawned each month, with the adult suffering normal adult mortality between spawning events. This results in an average adult female producing 17 544 eggs during her life once she has reached maturity. Table 3 outlines the parameters used with the life history model above, to give an estimate of a maximum of approximately four females for each female that reaches first spawning.

TABLE 3
Life history parameters used for the simple model used to estimate the maximum population growth rate in the absence of density dependent mortality. All parameters are taken from Oxenford *et al.* (2007).

Parameter	Estimate	Female survival	Spawning batch
Adult M ($month^{-1}$)	0.367	1.000	7 000
Larval Length (cm)	0.300	0.693	7 000
M_L ($month^{-1}$)	7.700	0.480	7 000
L_∞ (cm)	24.500	0.333	7 000
K ($month^{-1}$)	0.260	Larvae produced	17 544
Age maturity (months)	8.000	Larvae surviving to maturity	8 093
Length maturity (cm)	21.433	Females (R_0)	4 047

For purposes of the prior probability on R_0, Ln(4.047) was used as the mean of a log-normal, with a coefficient of variation of 50 percent. This covered the likely range of the true parameter, being not too restrictive, but representing the previous scientific research reasonably well. It might have been better to simulate the uncertainty using a Monte Carlo simulation including the error and uncertainty around the various parameters. However, there was insufficient time to apply this more sophisticated approach at this meeting.

2.3.2 Unexploited biomass (area and biomass/unit area estimates)

Tagging data: A single-census Petersen ratio method was used in an attempt to obtain a crude estimate of flyingfish abundance in the eastern Caribbean as the basis for a prior probability. In its simplest form, the tagging census requires two catching activities and one marking activity as follows. Firstly a sub-sample of individuals from the stock is captured, marked and released again (referred to as "first catch"). Subsequently, after a relatively short period of time has elapsed, a "second catch" is made and examined for marked individuals. The major assumption of this technique is that the ratio of marked to unmarked fish in the second catch is the same as the ratio of total marked fish to total fish in the stock. Abundance can therefore be estimated using the equation:

$$N = CM / R$$

where N = total number of fish in the stock, C = number of fish in the second catch, M = number of marked fish (i.e. number in the first catch) and R = number of recaptured marked fish.

The tagging experiment is reported in Oxenford (1994). The following data and analyses were used:

- Flyingfish were tagged off Tobago monthly from January to May 1989. A total of 3 460 fish were tagged and released over this period and represented the "first catch". Therefore, M = 3 460.
- Ice-boat catches of flyingfish purchased by the three main fish processing plants in Barbados from January to May 1989 were used as the "second catch". Therefore, C = 1 824 033.
- A total of 72 tagged fish were recovered by the three fish processors during the period January to May 1989. Therefore, R = 72.
- The estimate of stock abundance for the ice-boat fishing grounds (taken as a triangular area between Barbados, Grenada and Tobago, incorporating approximately 37 043 km^2) using these data is approximately 87 654 919 fish.
- Using the industry's accepted rough estimate of three flyingfish to the pound, this translates to 13 281 tonnes flyingfish or 0.3585 tonnes km^{-2}.

- Extrapolated to the entire Lesser Antilles Pelagic Ecosystem (LAPE) area (610 000 km^2), an upper estimate of flyingfish would therefore be 218 703 tonnes assuming equal distribution over the known stock range.

This "estimate" is crude, recognizing that certain assumptions of the Petersen method may not have been met, or may have been violated. Assumptions of the method are given below with comments relevant to this estimate.

Marked and unmarked fish must have the same mortality. The mortality impact of the marking technique used on flyingfish was not examined. However, it is reasonable to assume that it was minimal given the careful handling, very rapid tag application and immediate release, the extremely small size of the tags, and the lack of any signs of infection in any of the recaptures.

Marks must not be lost throughout the duration of the experiment. Again, this was not specifically tested for flyingfish, but was assumed to be minimal, given the small size of the tag and secure fastening.

Catchability (i.e. susceptibility to fishing gear) must be the same for marked and unmarked fish. Again, this was not specifically tested for flyingfish, but there was no *a priori* reason to suspect any change in catchability.

There must be no, or at least negligible, recruitment (new youngsters) and immigration to the stock during the experiment. Given the life history of flyingfish, it is reasonable to assume that there was no significant recruitment of new young into the fishable stock in the January to May period. However, the area being studied (triangle of sea between Barbados, Grenada and Tobago) is an open area and does not represent the full extent of the stock. As such, fish may well have been moving in and out of the area during the period. Therefore, the effective area of the experiment may be larger than that used resulting in a higher biomass estimate than in reality.

Marked fish must redistribute randomly throughout the stock upon their release. This may be reasonable given the fairly extensive movements known for flyingfish. However, there may be some tendency to remain together in the same schools. Lack of mixing will make the stock appear smaller than it really is.

A further consideration is that the degree of accuracy of the census will depend on the size of the two catch samples relative to the size of the stock. There are in fact charts available for relating the sizes of M (number of marked fish) and C (number of fish in second catch) necessary for a stated level of precision in a stock abundance estimate. A 50 percent level of precision is recommended for preliminary management surveys. If these guidelines are followed, the current estimate for population size would indicate that our tagged fish sample size was an order of magnitude too small. On the other hand, this is somewhat alleviated by a second capture size an order of magnitude greater than recommended. The latter is corroborated by a relatively high return rate of tagged fish.

Visual survey data: An alternative, totally independent, biomass estimate for *H. affinis* adapted from the FAO LAPE study (Mohammed *et al.,* 2008) based on survey data reported by Oxenford *et al.* (1995) gave a very similar estimate as the tag-recapture assessment above. This estimate used the total number of fish counted, extrapolated to population number in the surveyed area assuming that 10 percent of *H. affinis* took to flight and were therefore seen and counted during the passage of the survey vessel. For *H. affinis,* the reported sightings were 7 209 fish over 703 nautical miles of survey transect (Oxenford *et al.,* 2005). The area surveyed was computed as the product of the total distance surveyed and a bandwidth of 20 metres (10 metres surveyed on either side of the vessel, Mahon, personal communication) (1 302 x 0.02 km^2, i.e. 26 km^2). The population number for *H. affinis* was converted to the corresponding weight, assuming that all fish were at maximum size (30.5 cm total length [TL]) as reported by Samlalsingh and Pandohee (1992), and using the length weight parameters from Samlalsingh and Pandohee (1992) (i.e. a 30.5 cm TL fish weighs 172 grams). The estimated biomass of *H. affinis*, using these parameters, is 0.475 tonnes km^{-2}, which gives a total biomass of 290 911 tonnes over the LAPE area (610 000 km^2).

Finally, these estimates are for a stock under exploitation in one year, whereas the parameter of interest is a long-term average under no exploitation. Therefore, the estimate cannot be used as a fixed value, but only loosely to inform the assessment of a reasonable biomass range.

The prior was developed as a log-normal with the central tendency being the abundance estimate from the tagging described above. The scale parameter (CV or sigma) was chosen so that 97.5 percent of the density was above 1.5 times the maximum catch in the time series. This is arbitrary, but avoided probability mass at low population sizes which would not be supportable and provided a loose limit on the upper population size. A method which did not consider catch would be preferred. Because a weak prior was used, the crude nature of the abundance estimates should not have a significant impact except where there is no other information.

2.3.3 Other parameters

Catchability was assumed uniform on the log scale. This essentially makes this prior uninformative. The log scale was appropriate mainly because the population which it is used to scale is also treated as a log variable.

The overall error (observation and process error) was unknown and no attempt was made to fit it on this occasion. An estimate of the appropriate level of error was obtained by estimating the standard deviation of the residuals after smoothing the log-catch per unit effort (CPUE) series. The residuals, calculated as the difference between a moving average of the log-CPUE series and the actual values, suggested a CV of around 16 percent. Given that it is believed this stock is heavily influenced by the environment, this seemed a little low. For this assessment, a precautionary value of 30 percent was set and the error parameter was not fitted. This high error reflected the uncertainty in the dynamics. If this parameter is fitted, a proper prior reflecting this expectation might be developed rather than fixing the parameter.

As well as an overall error, another parameter was required to split the error between the process and observation errors. This was a simple variable varying from 0 (no process error) to 1.0 (all process error and no observation error), and the uniform distribution was used as an uninformative prior.

2.4 Precautionary reference points

There was only limited discussion on the appropriate reference points. It was agreed that reference points should be based on MSY and an appropriate target would be fishing mortality at 2/3 F_{MSY} and that the target biomass should be estimated on this basis. The limit reference point for biomass should be 0.5 B_{MSY} and a trigger point below which management should take action to allow biomass to increase should be B_{MSY}.

Development and use of these reference points presuppose that they can be estimated with reasonable precision. This is currently not the case.

2.5 Decision rule

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

As no decision rule has been agreed, several possible rules were explored in the projections based on possible scenarios. These were:

1. Maintain the current fishing mortality. The main policy would be to maintain the current fleet capacity (limit number of size of vessels and days at sea).
2. Target fishing mortality of 2/3 MSY, based on the current best estimate of MSY. This would allow fleet fishing effort to increase by a factor of 5.63, and would be based on a development policy in the fishery, encouraging investment in the fleet to increase capacity to a limit.
3. Maintain the current catch of 2 512 tonnes. This would involve capping landings by setting a TAC. This may prove difficult to enforce as flyingfish caught for bait are not landed. A landings TAC would have to take this into account.
4. Increase the current catch to 5 024 tonnes, double the current catch. As for the current catch, this would have to be controlled through a TAC.

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

2.6 Projections

Four projections were conducted and outcomes recorded in the form of the standard performance indicators used for the assessment (Figures 5–8). As the projections are stochastic, the indicators are recorded as frequencies taken over the 15 years of the projection. The projection takes into account the uncertainty in the estimates.

The projections show that keeping the fishing effort and capacity or catch at around 2 500 tonnes should be safe with overfishing very unlikely even with stock fluctuations due to environmental influences (Figures 5 and 7). In contrast, attempting to fix the fishing mortality in relation to MSY or set catches at or above 5 000 tonnes leads to a significant risk of overfishing (Figures 6 and 8). This is partly due to the uncertainty of what the appropriate MSY value is.

The conclusion is that current levels of fishing require little intervention and limited monitoring is acceptable. However, if the fishery is to be developed, and sustained catches approach 5 000 tonnes, increased monitoring and research will be required to ensure sustainable exploitation.

The projections suggest that a trigger point should be established at around 5 000 tonnes, such that when catches consistently exceed this figure management takes action preventing further increased exploitation until research can show that increased exploitation will not cause overfishing.

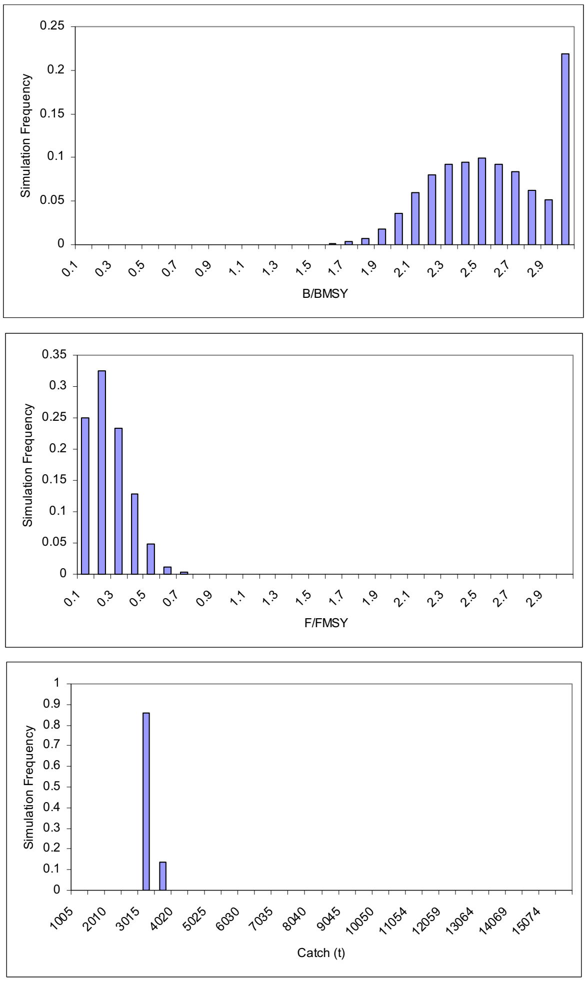


Figure 5. Current fishing mortality is constant.

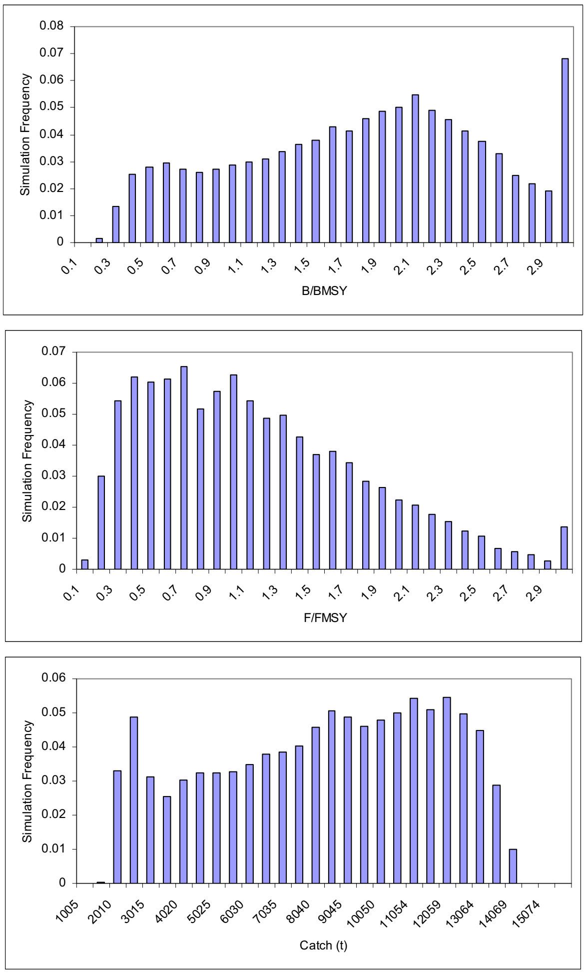


Figure 6. Fishing mortality set to 2/3 MSY.

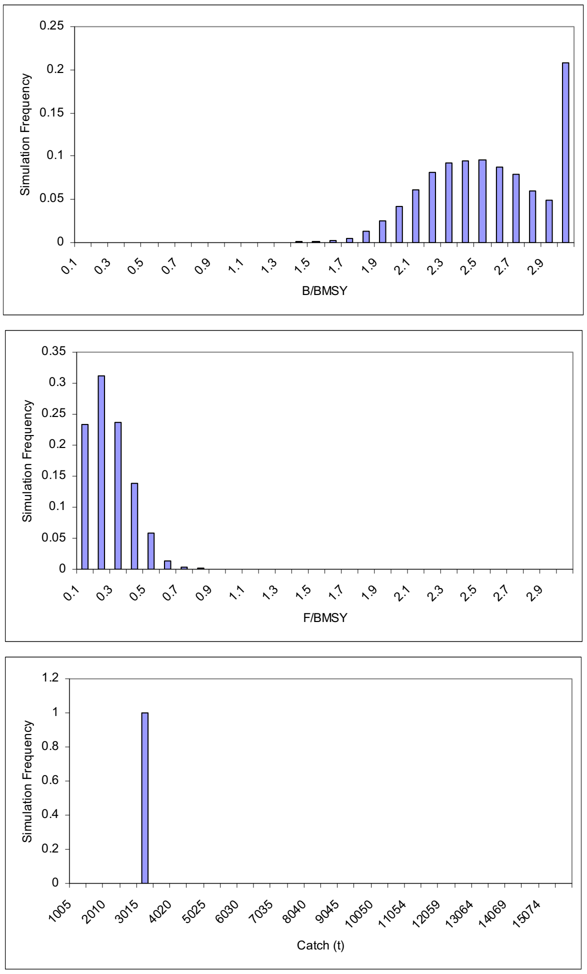


Figure 7. Current catch is kept constant at 2 512 tonnes.

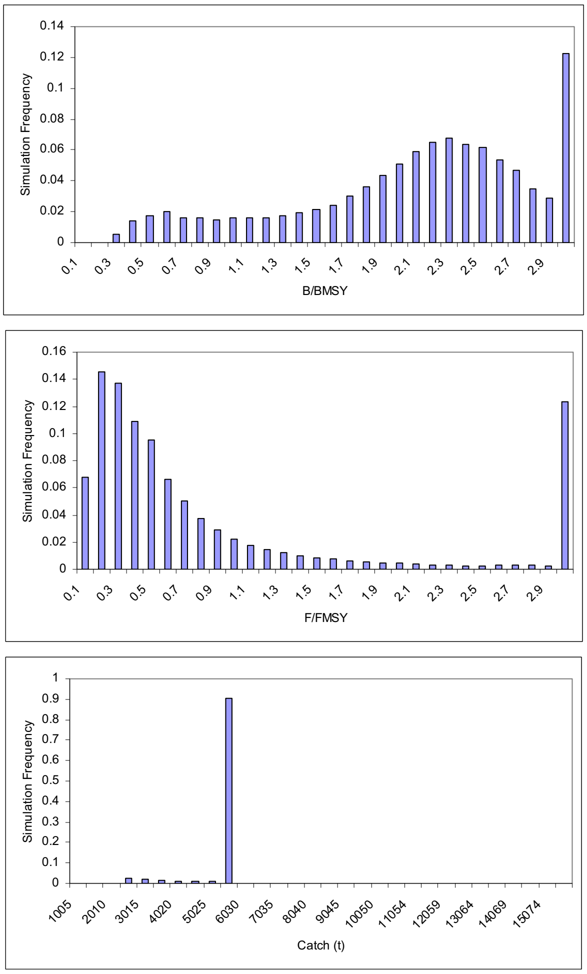


Figure 8. Catch is kept constant at twice the current level: 5 024 tonnes.

2.7 Recommendations

- **Improve estimates of catch and catch-effort time series.** Total catches are required not only for stock assessment, but also to monitor the level of exploitation and success of controls. Current estimates of total catch are relatively poor and should be improved. Catch and effort are used as indicators of stock size. If the level of exploitation should increase, improved catch and effort data should be collected. In any case, research on the relationship between abundance and CPUE would be valuable.
- **Improve model fitting.** Some improvements could be made to the model, including more categories approximating the stock recruitment relationship, separate catchabilities for the CPUE series and improved standardization of the CPUE series. Other approaches might include fitting the catch time series, which allow greater flexibility in the model form but would result in many more parameters and therefore a much lower accuracy in the numerical integration.

  The current model framework is chosen to simplify the procedure and avoid estimating the individual stock sizes as separate parameters. Estimating stock sizes in the Bayesian framework would require a further 53 parameters. Integrating over these parameters with the analytical function within the posterior calculation simplifies the fitting process at the loss of some flexibility. Moving to a Markov Chain Monte Carlo framework would allow full flexibility, but with a loss of accuracy and more complex fitting. Possible improvements to the model which could be explored would include:

- Changes to the process and observation error. The current error models are limited to the normal density function. Currently, the log-transform is used, but the identity or square root could also be proposed. The log-transform is likely to be most appropriate for the process error (stock-recruitment relationship), but the observation error could be better modelled using alternative forms. Given that the CPUE series is relative flat, it is likely that this assumption is not critical at this time.
- Monte Carlo simulation for the R_0 prior. Given more time, it would be better to simulate the prior for R_0 using a Monte Carlo simulation including the error and uncertainty around the various parameters.

- **Conduct a series of sensitivity analyses.** More sensitivity analyses need to be conducted to properly document the range of uncertainty. Some of these are suggested below. Sensitivity analyses should form an important part of the working group's terms of reference when it meets again.
- **Use the alternative Ricker to the Beverton and Holt stock recruitment model.** One of the sensitivity analyses should be to see whether the results are sensitive to the form of stock recruitment model.
- **Consider modelling oceanographic effects.** Oceanographic variables are available and might be used to explain some variability in stock size or CPUE. This needs to be carried out with great caution as it is very easy to introduce spurious correlations. Therefore, this should be done with the aim of developing alternative possible models as sensitivity analyses and environmental variables only used in the base model once the biological effect of the variable is fully understood.

3. TECHNICAL MODEL DESCRIPTION

3.1 Posterior calculation

In the following treatment, the spawning stock size (*S*) is treated as a log variable (*lS*). This is equivalent in this context as the log-normal, since the cumulative log-normal of the untransformed variable is the cumulative normal for the transformed variable.

The Bayesian probability of a particular stock size can be written:

$$P = \Pr(S_t | S_{t-1}, a, b, C_t)\Pr(CPUE|S_t)$$

Therefore, the stock size is conditional on the population parameters, previous stock sizes and the likelihood for the CPUE index. The stock size can be estimated as parameters, or removed analytically as nuisance parameters through integration. This last approach is adopted here to reduce dimensions and make analysis and interpretation easier.

The Beverton and Holt stock-recruitment relationship is non-linear and does not allow an analytical solution to the integration over all the previous year's stock size. The Posterior (*P*) can be approximated assuming fixed recruitment over an interval corresponding to a range of previous population size. This cuts the stock-recruitment relationship into a series of *n* intervals, which allows analytical solution to the integration approximating the integral of the non-linear relationship.

$$P=\sum_{i=1}^{n}\sum_{j=1}^{n}\int_{lS_{j-1}}^{lS_j}\frac{1}{\sqrt{2\pi}\sigma_p}e^{-\frac{1}{2\sigma_p^2}(lS-R_i)^2}\frac{1}{\sqrt{2\pi}\sigma_o}e^{-\frac{1}{2\sigma_o^2}(lCPUE-lS-lq)^2}\Pr(R_i)\quad dlS$$

Where R_i = log-recruitment from the previous population, $\Pr(R_i)$ = probability for the recruitment R_i (sums to 1.0 over the n intervals), σ_p = process error scale parameter, σ_o = observation error, $lCPUE$ = CPUE abundance index for the year and lq = log catchability.

$$P=\sum_{i=1}^{n}\frac{\Pr(R_i)}{2\pi\sigma_p\sigma_o}\sum_{j=1}^{n}\int_{lS_{j-1}}^{lS_j}e^{-\frac{1}{2\sigma_p^2}(lS-R_i)^2-\frac{1}{2\sigma_o^2}(lCPUE-lS-lq)^2}\quad dlS$$

This can be converted to a single exponential term containing the lS variable by completing the square:

$$P=\sum_{i=1}^{n}\frac{\Pr(R_i)}{2\pi\sigma_p\sigma_o}\sum_{j=1}^{n}\int_{lS_{j-1}}^{lS_j}e^{-\frac{1}{2\sigma_s^2}(lS-\mu_s)^2-\frac{1}{2(\sigma_p^2+\sigma_o^2)}(lCPUE-lq-R_i)^2}\quad dlS$$

where

$$\mu_s=\frac{R_i\sigma_o^2+(lCPUE-lq)\sigma_p^2}{\sigma_p^2+\sigma_o^2}$$

$$\sigma_s^2=\frac{\sigma_p^2\sigma_o^2}{\sigma_p^2+\sigma_o^2}$$

The integration can be solved using standard numerical functions:

$$\int_{lS_{j-1}}^{lS_j}e^{-\frac{1}{2\sigma_s^2}(lS-\mu_s)^2}\,dlS\quad=\quad\sqrt{2\pi}\sigma_s\left[\mathrm{N}(lS_j|\mu_s,\sigma_s)-\mathrm{N}(lS_{j-1}|\mu_s,\sigma_s)\right]$$

where $\mathrm{N}(x|\mu,\sigma)$ is the cumulative normal distribution.

$$P=\sum_{i=1}^{n}\frac{\Pr(R_i)}{\sqrt{2\pi}\sqrt{\sigma_p^2+\sigma_o^2}}e^{-\frac{1}{2(\sigma_p^2+\sigma_o^2)}(lCPUE-lq-R_i)^2}\sum_{j=1}^{n}\left[\mathrm{N}(lS_j|\mu_s,\sigma_s)-\mathrm{N}(lS_{j-1}|\mu_s,\sigma_s)\right]$$

Where there are no observations, the likelihood term is dropped and the calculation becomes:

$$P=\sum_{i=1}^{n}\Pr(R_i)\sum_{j=1}^{n}\left[\mathrm{N}(lS_j|R_i,\sigma_p)-\mathrm{N}(lS_{j-1}|R_i,\sigma_p)\right]$$

which clearly sums to 1.0. However, the calculation is necessary to obtain the recruitment values, R_i, which depends on the probability mass in each of the n intervals for the population in the previous year.

3.2 Including catches

Catches within the year will decrease the stock size. Catches mostly take place while the fish is actively spawning, so the main impact would be to reduce egg production and potentially recruitment the following year. This is most easily modelled by adjusting the integration over the stock-recruitment relationship:

$$P=\sum_{i=1}^{n}\frac{\Pr(R_i)}{\sqrt{2\pi}\sqrt{\sigma_p^2+\sigma_o^2}}e^{-\frac{1}{2(\sigma_p^2+\sigma_o^2)}(ICPUE-lq-R_i)^2}\sum_{j=1}^{n}\left[\mathrm{N}\left(\mathrm{Ln}\left(S_j+C\right)\middle|\mu_s,\sigma_s\right)-\mathrm{N}\left(\mathrm{Ln}\left(S_{j-1}+C\right)\middle|\mu_s,\sigma_s\right)\right]$$

and

$$P=\sum_{i=1}^{n}\Pr(R_i)\sum_{j=1}^{n}\left[\mathrm{N}\left(\mathrm{Ln}\left(S_j+C\right)\middle|\ R_i,\sigma_p\right)-\mathrm{N}\left(\mathrm{Ln}\left(S_{j-1}+C\right)\middle|\ R_i,\sigma_p\right)\right]$$

Where C = the catch taken during the year. This effectively removes the catch from the population directly before spawning, reducing the spawning stock and shifting the probability density function to the left. Note that the first interval probability ($\mathrm{N}(\mathrm{Ln}(C) \mid \mu_S, \sigma_S)$) is excluded from the sum (i.e. the population must exceed the catch). Loss of probability in this first term has a significant impact on fitting the population model. The probability describing the population status must be normalized to sum to 1.0, but the posterior is not adjusted and reflects this probability loss, making stock sizes close to the catches less likely.

The CPUE should also be adjusted, so the expected population size becomes $Ln\left(e^{ICPUE-lq}+0.5C\right)$. This accounts for the fact that the CPUE might be expected to decline due to catches within the year. However, no account is taken of natural mortality or other factors, so this index might benefit from reconsidering how CPUE might reflect abundance.

3.3 Fitting the model

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

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

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

2. Sampling importance takes random samples from the approximating PDF and calculates a weight based on the ratio between the approximating function value and the target function. These weights can be used to apply a correction to the integration, as well as form the basis of the resampling step of the Sample-Importance-Resample (SIR) algorithm. The SIR algorithm attempts to generate a draw of parameter values from the target function with

equal weight. The sampling importance has the advantage over the rejection algorithm in that the approximating function need not cover the target function. It is generally not possible to guarantee that the target function is covered across its whole range in a large number of dimensions, so SIR may be the best option for difficult cases. The problem with the method is that the accuracy can be poor, as indicated by a wide range of weights, a problem which can only be addressed by an improved approximating function.

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

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

The method is applied as follows:

1. Make a random draw of the variables from the current approximate density.
2. Calculate the approximate and target function values and the difference between the two.
3. IF the approximate function is greater than or equal to the target function, THEN accept the values with probability (Target F)/(Approximate F), otherwise reject them OR accept the importance sample recording the importance ratio if the importance ratio is not too high.
4. ELSE the approximate function is less than the target function OR the importance ratio is too high, so add another normal kernel to the approximate density:
   (a) Find the mode of the difference function being the target minus the approximate function.
   (b) Calculate the kernel weight as the ratio of the height of the kernel normal to the height of the difference function.
   (c) At the mode, calculate the hessian matrix (partial differential matrix) and invert it. The inverted hessian matrix is covariance matrix for a multivariate normal distribution. Adjust the estimated matrix to best fit the local difference function and ensure the matrix is a valid covariance matrix (positive definite).
   (d) Add a “kernel” multivariate normal to the approximating mixture PDF with mean equal to the mode and covariance matrix to the estimated matrix above.
   (e) Repeat actions (a) and (c) until the original point is covered (target F – approximate F < 0 OR importance ratio is acceptable)
   (f) Discard all the draws from the target function to restart.
5. Repeat actions 1 to 4 until the required number of draws have been made.

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

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

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

The method has been implemented using Visual Basic in a Microsoft Excel spreadsheet. While this implementation is numerically slow, it was considered useful in developing the method to use spreadsheet based functions and data storage as these are most flexible in setting up models and monitoring the behaviour of the fitting algorithm. The full code and spreadsheet are available on request (paul.medley@virgin.net).

4. REFERENCES

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

Hilborn, R., & Walters, C.J. 1992. Quantitative Fisheries Stock Assessment. Choice Dynamics and Uncertainty. Chapman and Hall, New York.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. *Journal of Fish Biology*, 49: 627-647.

Mahon, R. 1989. Developing a management strategy for the flyingfish fishery of the eastern Caribbean. Proceedings of the Gulf and Caribbean Fisheries Institute 39: 389-402.

Mohammed, E., Vasconcellos, M., Mackinson, S., Fanning, P., Heileman, S. & Carocci, F. 2008. A trophic model of the Lesser Antilles pelagic ecosystem. Technical Document No. 2 of Scientific Basis for Ecosystem-Based Management in the Lesser Antilles including Interactions with Marine Mammals and Other Top Predators. FAO, Barbados, FI:GCP/RLA/140/JPN, 168pp.

Oxenford, H.A. 1994. Movements of flyingfish (*Hirundichthys affinis*) in the eastern Caribbean. Bulletin of Marine Science 54: 49-62

Oxenford, H.A., Mahon, R. & Hunte, W. 1995. Distribution and relative abundance of flyingfish (Exocoetidae) in the eastern Caribbean. I. Adults. *Marine Ecology Progress Series*, 117: 11-23

Oxenford, H.A., Mahon, R. & Hunte, W. 2007. Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, University of West Indies, Barbados, 267pp.

Samlalsingh, S. & Pandohee, E. 1992a. Preliminary stock assessment for the flyingfish fishery of Tobago. Technical Report of the Project for the Establishment of Data Collection Systems and Assessment of the Fisheries Resources. FAO/UNDP: TRI/91/001/TR11, Port of Spain, Trinidad: 41 pp.

Samlalsingh, S. & Pandohee, E. 1992b. Stock assessment parameters for the flyingfish, (*Hirundichthys affinis)*. Technical Report of the Project for the Establishment of Data Collection Systems and Assessment of the Fisheries Resources. FAO/UNDP: TRI/91/001/TR3, Port of Spain, Trinidad. 8 pp.

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

PART III: NATIONAL REPORTS

National report of Barbados: description of data used

Christopher Parker

Fisheries Division
Princess Alice Highway
Bridgetown, Barbados
E-mail: fishbarbados.fb@caribsurf.com

BACKGROUND

Flyingfish accounted for approximately 62 percent of fish landings in Barbados over the period 1998–2007. The island's ice-boat and day-boat fleets land the majority of the islands flyingfish catch (typically over 90 percent). In 2007, there were 167 ice boats and 242 day boats registered in the Barbados fishing fleet. A more detailed description of the Barbados flyingfish fishery may be found in Parker (2002a and 2002b).

STATISTICS USED IN ANALYSES

The history and methodology for recording fish landings statistics in Barbados has been previously described in detail in Parker (2002b). In summary, landings data has been collected at various landing sites around the island since the late 1940s. From mid-1993 the Fisheries Division began systematic computerized recording of landings using a computer programme provided through the CARICOM Fisheries Resource and Assessment Management Programme (CFRAMP) specifically to manage fisheries data known as the Trip Interview Program (TIP). Toll-book records 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 (TIP and LRS) using the vessel registration number as a common variable it was possible to link specific vessel information to respective catches. This facilitated the calculation of mean catch per unit effort (CPUE) data per vessel type (i.e. day boats and ice boats, etc.).

However, over time registration numbers were often reassigned to totally different vessels (and types of vessel). The LRS system did not offer an ongoing archiving facility and as a result past landings records would be linked to current vessel information, which resulted in the incorrect assignment of vessel specifications to historic landings in cases where the registration number had been assigned to a different vessel during the intervening period. To address this issue it was necessary to manually recreate the vessel record database for each respective time period and link the landings data to the respective recreated vessel register. It should be noted that this methodology was used to obtain the data used in the 2001 stock assessments.

In 2005, the Barbados Fisheries Division started to use a new computerized catch recording programme *viz* the Caribbean Fisheries Information System (CARIFIS), produced under the auspices of the Caribbean Regional Fisheries Mechanism (CRFM). In addition to this, a complementary custom-designed vessel and fisher registration database programme (Fisheries Information System for Barbados [FISBARB]) developed in-house at the Barbados Fisheries Division was also put into use. The two databases are linked through unique hull numbers assigned to the vessels rather than registration numbers. The system also allows for archiving of the licensing registration information, and thus accurate linking of historic catch and contemporaneous vessel information is facilitated. During 2005, the Fisheries Division, in collaboration with Dr Paul Fanning, Director of the FAO's Lesser Antilles Pelagic Ecosystem Project, undertook rebuilding the historic vessel database for the preceeding ten years based mainly on hardcopy registration files. While it was not possible to positively identify all the vessels for which landings records have been recorded in past years, the vast majority of historic catches can now be accurately linked to the correct vessels and their associated technical specifications during that ten-year period.

Prior to 1994, most of the statistics still available on the island's fish landings are summarized data to no finer detail than daily totals of each category of fish landed at the site and the total number of vessels landing fish catches on the respective day. In addition, the activities of the ice boats were not recorded separately from day boats in the fledgling years of the development of the ice-boat fleet. In an effort to extend the time series of landings for ice boats, landings data recorded in toll-book ledgers for the period November 1988 to December 1993 (inclusive) from the Oistins Fishing Complex were reviewed and the flyingfish landings data for the ice boats extracted. Mean monthly CPUEs (effort being trips) were then calculated from these data. These were then combined with the mean monthly CPUE values for ice boats (from all landing sites) from 1994 to the present as per the data recorded in the computer database. In this way it was possible to develop a contiguous time series of 20 years (1988–June 2008) for ice-boat flyingfish CPUEs.

Time constraints made it impossible to complete a similar data extraction for day boats prior to the assessment meeting. As a result, mean CPUE (effort being trip) indices were only calculated from the computer databases for the period 1994 to June 2008.

REFERENCES

Parker, C. 2002a. Developments in the flyingfish fishery of Barbados. *In* FAO (ed.) The Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. Bridgetown, 8–12 January 2001. *FAO Fisheries Report.* No. 670. pp. 76–93.

Parker, C. 2002b. Preliminary analysis of the flyingfish fishery of Barbados and interim recommendations. *In* FAO (ed.) The Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. Bridgetown, Barbados, 8–12 January 2001. *FAO Fisheries Report.* No. 670. pp. 35–47.

NATIONAL REPORT OF SAINT LUCIA

Patricia Hubert-Medar

Department of Fisheries
Castries, Saint Lucia
Tel.: (758) 468-4134/5
Fax: (758) 452-3858
E-mail: deptfish@slumaffe.org

BACKGROUND

Traditionally, flyingfish have been targeted by many Saint Lucian fishers. Early technology comprised the use of a shallow dip net (locally known as a "kali") to scoop up flyingfish found in aggregations or attracted by some form of artificial raft (often banana leaves tied to the vessel). Finely chopped fish ("fresh") was often thrown into the sea as an added attraction. This methodology is still in use today; however, surface handlines (with single hooks) and surface gillnets are also commonly used. The surface gillnet (fillet) is set approximately nine metres from the boat and then pulled alongside as the fish gather within it. Usually the net is used to encircle and trap fish that have been attracted using an artificial raft. A dip net is then used to scoop up the entrapped fish and then the net is hauled into the boat, usually by a crew of three, where any gilled fishes are removed. The net is then reset until sufficient fish are captured or the boat moves to locate another school.

The majority of vessels used are now open fibreglass pirogues. This vessel type has recently replaced the traditional wooden canoe as the dominant craft within the fisheries sector. When targeting flyingfish, most fishing trips focus on areas 10 to 15 miles offshore primarily off the northwest and southwest coasts of the island. The average trip starts early in the morning with fishers returning in the late afternoon or evening, some 10 to 12 hours later.

Flyingfish landings are heavily dominated by the fourwing flyingfish, but at least one other species – the larger *Cypselurus cyanopterus*, locally known as "denn" – forms a small part of the catch. The fishery tends to be seasonal, occurring mostly between the months of October and July, but seasonality varies from year to year with peak landings occurring anywhere between December and February and then May to June.

The majority of fishing vessels in Saint Lucia catch flyingfish during the flyingfish season; however, more fishing vessels from the west coast communities of Gros Islet, Castries, Anse La Raye, Canaries, Soufrière, Laborie and Choiseul target flyingfish compared with communities on the east coast.

Over a five-year period (2003–2007), the flyingfish landings have been variable with peak landings recorded in 2003 (75 tonnes) and total landings over the said period being just over 200 tonnes.

TABLE 1
Estimated flyingfish landings (2003–2007)

Year	2003	2004	2005	2006	2007
Landings (tonnes)	75	11	72	30	46

Source: Department of Fisheries, 2007.

Two landing sites where flyingfish comprise an important component of the catch remain unsampled (Anse La Raye and Canaries). This may lead to some error in estimating annual landings. Presently, bump-up procedures consist of raising sampled catches for non-sampled boats and non-sampled sites.

The fishing fleet

Presently, a total of 721 vessels are registered with the Department of Fisheries, with 46 percent involved in flyingfish fishing. These vessels range from 5–9 metres in length and are mainly powered by 40–115 hp outboard engines. They usually fish up to 15 miles offshore. Table 2 shows a summary of the vessel types engaged in flyingfish fishing at sites on the west coast where the flyingfish fishery primarily operates.

TABLE 2
Flyingfish fishing fleet by site

Site	Pirogue	Canoe	Shaloop
Gros Islet	36	2	3
Castries	43	2	4
Anse La Raye	15	12	1
Canaries	10	17	1
Choiseul	29	22	2
Laborie	30	2	3
Soufrière	45	48	8

Source: Department of Fisheries, 2007.

The typical vessel engaged in the flyingfish fishery measures 25 feet long and 5 feet wide. Table 3 shows the length distribution for the four different classes of vessels involved in flyingfish fishing.

TABLE 3.
Vessel length distribution (feet)

Vessel type	<19	20–30	31–40	Total
Canoe	72	414	2	488
Pirogue	18	103	1	122
Shaloop	5	24	0	29
Total	95	541	3	639

Source: Department of Fisheries, 2007.

The fishers

Generally, many Saint Lucian fishers do not focus on flyingfish fishing as a viable fishing activity. The majority of fishers, particularly those operating out of the south and east coasts landing sites, appear to be distracted during periods of peak availability for larger pelagic species, for example, dolphinfish, tuna, wahoo, that are most abundant during the first half of the year. Therefore, little effort is spent on targeting flyingfish and considerable scope may exist for increasing landings by increased effort within this fishery (George, 1999).

TABLE 4
Geographical distribution of fishers

Site	Full-time	Part-time	Non-fisher	Total
Anse La Raye	65	47	7	119
Anse Ger	2	0	0	2
Banannes	46	43	10	99
Canaries	53	38	6	97
Castries	151	113	12	276
Choiseul	106	38	8	152
Cul De Sac	0	1	0	1
Dennery	166	94	30	290
Gros Islet	128	79	6	213
Laborie	86	46	8	140
Marisule	6	12	1	19
Micoud	118	101	0	219
Monchy	6	8	0	14
Praslin	33	19	3	55
River Doree	16	10	0	26
Roseau	1	1	0	2
Savannes Bay	34	8	5	47
Soufrière	96	63	8	167
Vieux-Fort	252	146	37	435
Total	**1 365**	**867**	**141**	**2 373**

Source: Department of Fisheries, 2007.

MANAGEMENT OF THE FLYINGFISH FISHERY

The “Plan for Managing the Fisheries of Saint Lucia” highlights sustainability of the fishery as the primary management objective for the flyingfish fishery. It also notes that the selection of specific management options for this fishery should be largely dependent on development of a subregional approach to management of this shared stock.

Clearly, Saint Lucia’s present system of data collection and analysis contributes only modestly to the regional information base available for this straddling stock. Past regional research has suggested that Saint Lucia targets part of a stock shared by the southeastern Caribbean, i.e. by the islands of Dominica southward to Trinidad and Tobago.

Currently, flyingfish landings are estimated, tabulated and reported on an annual basis, along with estimating catches for a number of other major species groups. Such information is made available to fisheries personnel, fisheries managers, and key public and private sector agencies. Biological data are not yet available for this fishery.

Access to this fishery remains open. The only restriction facing this fishery is a regulation stipulating a minimum mesh of 19.05 mm for all nets.

The action plan for management of the flyingfish fishery (based on the fisheries management plan) is to provide support to regional initiatives aimed at establishing a regional management plan for the fishery (including assisting in the generation and use of scientific data, and participating in regional seminars and workshops aimed at devising such a plan); and to improve the local collection of catch/effort and biological data relevant to the fishery. Constraints on implementing such actions in the short term include the shortage of manpower and finances faced by the Department of Fisheries. (George, 1999).

REFERENCES

Hubert, P. 2000. Review of the social and economic status of the flyingfish fishery in Saint Lucia. Unpublished.

George, S. 1999. Fisheries sector review for Saint Lucia. OECS/NRMU/Government of Saint Lucia, Department of Fisheries. Data Management Section.

NATIONAL REPORT OF TRINIDAD AND TOBAGO

Kenneth Caesar[1], Elizabeth Mohammed[2], Arthur Potts[3], Earle Nichols[1], Darion Frasier[1], Michelle Smith[1], Keon James[1] and Garth Ottley[1]

[1] Department of Marine Resources and Fisheries, Tobago House of Assembly: kcaesar_2000@yahoo.com
[2] Fisheries Division, Ministry of Agriculture, Land and Marine Resources: emohammed@malmr.gov.tt
[3]University of Trinidad and Tobago, c/o Institute of Marine Affairs: arthur.potts@utt.edu.tt

DESCRIPTION OF THE FISHERY

The flyingfish fishery continues to be much the same as described in Potts *et al*. (2002) and Samlalsingh *et al.* (2007). The fishery is centred on the capture of the fourwing flyingfish (*Hirundicthys affinis*) and is located on the Caribbean Sea coast of the island of Tobago, which is located northeast of the island of Trinidad. The fishing range stretches from just off Charlotteville in the north leeward part of the island to Crown Point in the southwestern part of the island. Although there are about ten landing sites within the range of the flyingfish fishery, only three major landing sites for flyingfish are identified: Pigeon Point, Buccoo Point and Mount Irvine Beaches. This may be as a result of the location of the major processing plants which are close to these beaches in the southwest of the island. It has been reported that some fish is also landed at the Scarborough Port by the larger ice boats. The amounts, however, are considered to be negligible as the ice boats focus on the more high valued large pelagics. In 2008, the major landing sites were reported to be Pigeon Point (Wind Hole), Pigeon Point (Milford Bay), Mount Irvine Bay, Buccoo Point, Bon Accord Lagoon, and the Scarborough Fish Port.

The flyingfish fishery is also linked to the large pelagic fishery of the island of Tobago. This fishery targets species such as dolphinfish (mahi mahi), kingfish, wahoo and albacore, which all feed on the flyingfish. The main fishing craft used in the fishery is the fibreglass pirogue with sizes ranging from 22 feet to 32 feet. Records of the Department of Marine Resources and Fisheries show the number of boats involved in the fishery for the period 1988 to 2008 ranged between a minimum of 29 in 2000 and 61 in 1993, with an average of 50 boats per season. In 2008, there were 51 artisanal pirogues and 8 ice boats fishing the fishery (T. Holmes, personal communication, 2008). Currently, the main type of gear used in the fishery is the large monofilament gillnet. The dimensions are 6 to 10 metres long, 2 to 4 metres deep, and with a stretched mesh of 44 mm. This net is tied to the boat and suspended in the water in a process called “drifting”.

Fishers and fishing communities

The oceanic pelagic fishery historically has been the most important commercial fishery in Trinidad and Tobago. Between 1988 and 2008, the flyingfish fishery employed, on average, from 58 to 126 fishers. Prior to 1993, the pelagic fleet consisted of open wooden (bumboats) sailing boats of about 12 feet in length and propelled by oars. Following extensive damage to the fishing fleet by Hurricane Flora in 1963, and supported by the provision of credit facilities and subsidies by the government, the fleet was largely replaced by motorized vessels (as per records of the Department of Marine Resources and Fisheries, Tobago House of Assembly). Many young men choose fishing as a career after completing their secondary education. Only a small percent work full-time. The majority work for their relatives or some other investor’s vessel on a regular or part-time basis. Retirees purchase vessels and hire crew to work, thereby adding to the investment in a growing industry. Training towards obtaining the launch captains’ and engineers’ licence is an ongoing activity. The principal trainer used to be a staff member of the Department of Marine Resources and Fisheries. The Maritime Services Division conducts examinations twice yearly.

The fishery is centred on Tobago's Caribbean coast and located between Parlatuvier Bay on the north coast and Kilgwyn Bay on the southwest coast (much of Kilgwyn is now lost due to major expansion of the Crown Point International Airport). Associated fish areas are off Parlatuvier, Castara, King Peter's Bay, Great Courland Bay, Black Rock Bay, Mount Irvine Bay, Buccoo Bay, Pigeon Point Bay, Store Bay and Kilgwyn Bay. The greatest activity related to fishers, boats, fishing trips, catches and the resources are found at Pigeon Point, Buccoo and Mount Irvine Bays.

Prior to 1960, the Tobago flyingfish drift fishery was important only for the supply of bait fish. The bait was used in the trolling fishery of larger ocean pelagics such as tuna (*Thunnus albacares),* dolphinfish *(Coryphaena hippurus),* wahoo *(Acanthocybium solandri)*, among other species. The flyingfish fishery is now important to Trinidad and Tobago and a number of other Caribbean countries. Tobagonians learned the important techniques required to capture and debone the flyingfish as early as 1962.

In the early 2000s the Department of Marine Resources and Fisheries found that in Tobago a large percentage of the fishers were under the age of 49 and that the island had been experiencing a number of young persons entering the fishery. Households in a number of the fishing communities depended to some extent on the trade for livelihood. Some unemployed persons assisted in offloading the catch and deboning. About 68 percent of the workers had a primary-level education, 30 percent had secondary education, and 2 percent had post-secondary education. There were about 228 fishermen actively involved in the fishery (drifting and trolling), representing some 22 percent of the registered fishers. One hundred and twenty-six boats representing 18 percent of the Tobago fishing fleet were involved in the fishery.

Fisherfolk organizations

Fishers who fish flyingfish come under two main fisherfolk associations: All Tobago Fisherfolk Association (ATFA), which claims to represent all fishers in Tobago; and Southwest Fisherfolk Association, which claims to represent fishers who operate out of the ports identified as flyingfish landing sites. At a consultation held on 30 June 2008, various concerns were expressed by fisherfolk regarding the industry.

Some of these concerns included:

1. the impact of the gas and oil exploration activities on traditional fishing grounds;
2. the lack of adequate infrastructure (jetties, security, storage) at landing sites;
3. the need for more subsidies in the industry; and
4. the need for training.

Flyingfish processing, marketing and export

Between 1998 and 2008 the flyingfish processing plants employed on average some 200 persons, mainly women in the deboning of fish and the packaging of flyingfish fillets. However, now there are only three flyingfish processing plants operating in Tobago: Jacobs Fishing Enterprises Ltd in Bon Accord Estate; Crompston Fish Supplies Ltd at Store Bay Local Road; and Tobago Fish Supplies on Wilson Road, Scarborough. Between 2004 and 2008, two major flyingfish processing plants at the Industrial Park in Lower Scarborough – Terry Swan Ltd. and Tobago Seafoods Products – ceased operations. The current umbrella body for fisherfolk in Tobago, the ATFA, has indicated an interest in reopening and operating one of these plants.

The closure of the two processing plants and the current challenges being experienced by the existing plants are linked to a shortage of labour, in particular "deboners". Many deboners have started their own private businesses on the beach or are employed with various state-run employment programmes. In addition, some processors complain of the lack of proper cold-storage facilities to accommodate the blast freezing of large quantities of flyingfish. With the closure of the two plants, the existing plants have been unable to absorb the increase in supply of flyingfish from fishers due to unavailability of adequate cold-storage facilities. Flyingfish processing involves the filleting and removal of bones from the fresh fish. The fish is then packaged in vacuumed-sealed plastic pouches for sale as fresh frozen fillets.

Since all coastal communities around the island depend greatly on the fishing fleet and their activities for daily sustenance, small (processing) cottage industries have developed. These industries supplement the income of several households. One cottage industry can at times produce on a daily basis between 40 and 50 kg of processed flyingfish.

Flyingfish is purchased whole from fishers at both wholesale and retail prices. During the 2007/2008 fishing season, flyingfish retailed at TT$4.40 to TT$6.60 per kg. The wholesale price ranged from TT$2.86 to TT$3.30 per kg. Filleted flyingfish over the 2007/2008 period retailed at TT$10.00 per pack of five fillets. Approximately 75 to 80 percent of the processed flyingfish continues to be exported. Between 1995 and 2005, exports of flyingfish have varied between 50 and 200 tonnes and the export value has ranged between TT$1 and TT$4.8 million (Figure 1). Although exports since 2001 have remained above 125 tonnes and export value above TT$3 million, a considerable decline was experienced in 2005 to just over 50 tonnes valued at TT$2.5 million.

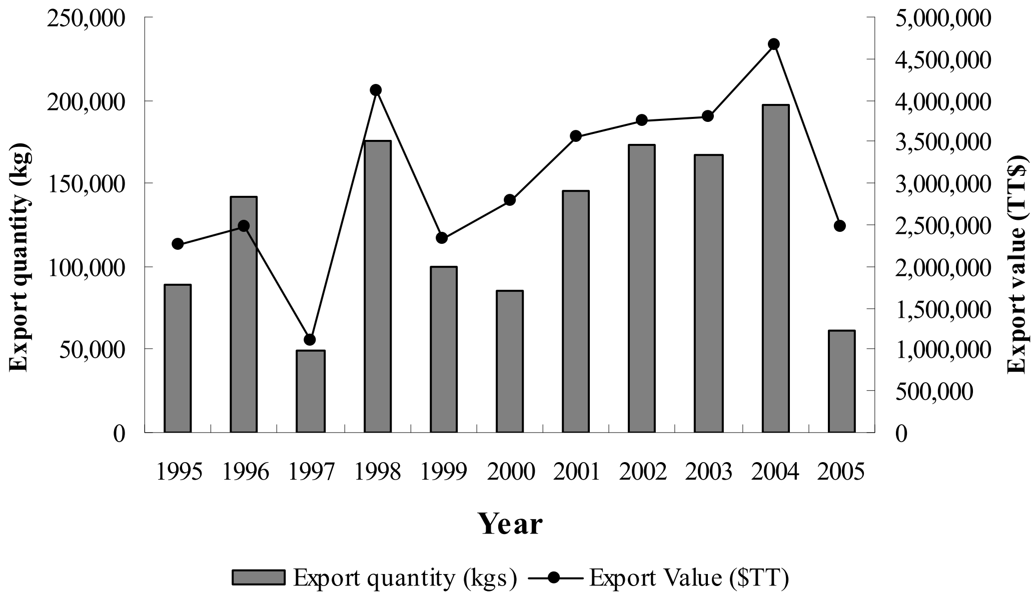


Figure 1. Export quantities and export values for the period 1995 to 2005. (Data source: Central Statistical Office.)

Impacts of multisectoral use of the coastal zone

Various multisectoral activities occur in the marine coastal zone and watershed areas that impact directly on the flyingfish fishery in Tobago.

Oil and gas exploration: Between November 2005 and June 2006, Petro-Canada conducted a 3D seismic survey in an estimated area of 3 100 square kilometres off the north coast of Tobago. During the survey, the seismic vessel towed six streamers approximately 6 000 metres long, each spreading 800 metres. These streamers carry sensors which detect pulses of sound from the substrata as a result of high pressure explosion generated by the seismic vessel. During the survey, fishers were frequently encountered by the seismic vessel at sea and were requested to cease fishing and clear the area. Since the conduct of the seismic survey coincided exactly with the flyingfish season (November to June), fishers claimed that the activity of the seismic vessel was responsible for the decline in catches experienced in the 2005–2006 fishing season. Fishers also contended that the seismic activity scared the fish away from the fishing grounds and caused physical damage to the fish. As a result, fishers were compensated by the company for the associated loss of earnings. Fishers have also attributed the low catches between September 2007 and August 2008 to exploratory drilling conducted by Petro-Canada off the north coast of Tobago (named Block 22). Between mid-June 2008 and mid-July 2008, Petroleum Eservices, on behalf of the Government of Trinidad and Tobago, conducted a 2D seismic survey around the coast of Tobago in waters stretching from 6 nautical miles to about 40 nautical miles out to sea and fishers were also compensated for the loss of earnings.

FAD fishery: Fish aggregation devices (FADs) are utilized in both the flyingfish (drifting) fishery as well as the fishery targeting large pelagic species with pelagic lines. Entanglement of gillnets used in the flyingfish fishery with FADs set in the pelagic fishery is a source of conflict between the fishers exploiting both fisheries. Nevertheless, it has been argued that the flyingfish fishery also benefits from the use of FADs as these devices are integral to the fishing strategy (called “drifting” or “lurking”, as described in Samlalsingh *et al*., 2007) which relies on the attraction of mature flyingfish to the FADs for the purpose of attaching their negatively buoyant eggs.

Ice boats vs pirogues: The perception that fishers who utilize ice boats are able to exploit the flyingfish fishery to a greater extent compared with fishers who utilize pirogues is a source of some tension between both groups. Pirogues (also called day boats) usually leave their home port between 6 a.m. and 8 a.m. and return between 4 p.m. and 6 p.m., while ice boats can stay out at sea fishing for up to five days. In addition, fishers with ice boats are able to fish further out at sea than those who utilize pirogues.

Marine recreational activities: The major impact of this multisectoral activity on the flyingfish fishery relates to the ability of fishers to access fishing grounds and landing sites unhindered by the other users of the marine space. Most of the flyingfish fishers fish out of ports and land their catch at sites in the southwestern part of the island of Tobago at Pigeon Point, Mount Irvine, Buccoo Point and Plymouth/Black Rock. These areas are also utilized for a variety of recreational activities such as jet-skiing, SCUBA diving, parasailing, windsurfing and reef tours. There is, therefore, competition between these users and the fishers for berthing space and boating lanes.

Fishery management

Exploitation of the flyingfish resources off Tobago by fleets from Barbados was regulated under a 1991 Bilateral Fishing Agreement between the Governments of Trinidad and Tobago and Barbados. However, currently, all fisheries in Trinidad and Tobago are open access. Experiences worldwide have shown that open-access fisheries lead to overcapitalization and, ultimately, overexploitation. There is, therefore, critical need to implement resource management approaches aimed at long-term sustainability and food security in general. As a result, in 2007, Trinidad and Tobago updated its policy for the marine fisheries sector and drafted supporting legislation (Fisheries Division, 2007; Moore-Miggins and Company and Scales Consulting Ltd, 2006). The issues addressed by the revised policy include: (i) open access; (ii) national, regional and international fisheries and management obligations; (iii) fisheries monitoring, surveillance and enforcement; (iv) transparent decision-making through stakeholder involvement and consultation; (v) protection of critical fish habitat; (vi) integrated coastal zone management; (vii) safety and security of fishers; (viii) fisher compensation for loss or disruption of livelihood; (ix) consideration of the social impacts of fisheries management and impacts of multisectoral use of the coastal zone on fisheries; and (x) improved infrastructure to meet international sanitary and phytosanitary standards.

Challenges to management

There are a number of challenges faced in the management of the fisheries of Trinidad and Tobago. These include, but are not limited to, the finalization of the updated national fisheries policy and supporting legislative framework; and the adequate staffing of both the Fisheries Division, Trinidad, and the Department of Marine Resources and Fisheries, Tobago, with well-trained, competent staff to conduct the varied and complex duties of a modern fisheries administration. Additionally, there is the need for a Fisheries Monitoring, Surveillance and Enforcement Unit in Tobago. This will ensure a unit separate and apart from the Extension Services Unit, charged with the responsibility of ensuring that fishers adhere to the legislation, rules and regulations. There is also need to consider other, more valuable, large pelagic species caught in association with the flyingfish in developing a management strategy. The issue of illegal, unreported and unregulated (IUU) fishing by foreign fleets and the need for a vessel monitoring system (VMS) cannot be overemphasized. At present, data is collected on some beaches by a few data collectors for some hours of the day only on working days. This results in inadequate data to inform decision-making and therefore the management of the fisheries. Steps must be taken to address this situation. There is also the need to strengthen institutional structure to address the multifaceted requirements of management and for meeting obligations under international conventions to which Trinidad and Tobago is signatory.

DATA COLLECTION, COMPUTERIZATION AND ANALYSIS

A description of the data collection system in Tobago, with emphasis on the drifting fishery, is provided in Potts *et al*. (2000). Currently, there are four catch and effort data collectors based at the Department of Marine Resources and Fisheries, three of whom collect catch and effort data at eight landing sites, while the fourth data collector files, computerizes and summarizes the data. Data are collected four days per month at Charlotteville, Mount Irvine and Castara; six days per month at Plymouth, Roxborough and Studley Park; and eight days per month at Pigeon Point and Buccoo Point. Data are not collected at the Bon Accord Lagoon, an important landing site for the drifting fishery. A customized data sheet had been developed for the drifting fishery during the Eastern Caribbean Flyingfish Project and modified during the CARICOM Fisheries Resources Assessment and Management Programme (CFRAMP). However, use of this data sheet was discontinued three years ago. Instead, a generic data sheet, used for other fisheries and with fewer requirements, is being used to collect information on the drifting fishery. The trip report form that was introduced during the CFRAMP is still being used. Hard copies of data are filed by landing site in decreasing chronological order.

The software utilized and data fields computerized for the drifting fisheries have varied over the last 20 years (Potts *et al.*, 2000). Between 1988 and 1997, catch and effort data for this fishery were computerized by the Fisheries Division in Trinidad. Initially an R-Based system was used and by the mid-1990s DBase IV was used. In 1998, all previously computerized data were imported in Microsoft Excel format. In 1998, the Department of Marine Resources and Fisheries began utilizing the Trip Interview Program (TIP) introduced under the CFRAMP to computerize catch and effort data for all fisheries in Tobago. However, due to a decrease in staff trained to utilize the TIP and a lack of local technical expertise to troubleshoot and resolve database problems, the Department of Marine Resources and Fisheries switched to computerization of fisheries catch and effort data in Microsoft Excel from 2005. Due to a loss of institutional memory, data computerized between 1998 and 2004 are not available. Currently, trip report data are computerized along with selective data fields from the catch and effort data sheets (species, catch quantity, boat number and date).

Prior to 1998, total landings of flyingfish were estimated from recorded data as described below. Data recorded since 1998 have not been adjusted to account for non-enumerated fishing days and landing sites to arrive at an estimate of total landings. However, it is felt that a system similar to that used in Trinidad could be introduced. Such a system requires periodic conduct of a boat census. In Tobago, a boat census was conducted in 1991 (under the FAO project mentioned previously).

Catch data

Point estimates of flyingfish total catch are available for 1957, 1974 to 1984, 1988 to 1997, and 1998 to 2008. These estimates were derived as described below.

1957**:** King-Webster (1957) and King-Webster and Rajkumar (1958) provided estimates of catch rates for boats utilizing specific gear (banklines, troll lines, beach seine, fish pots). Only one vessel was described as using a "fillet net" (gillnet). It was assumed that the entire catch of this gear comprised flyingfish since the gear was introduced specifically to target the species in Tobago. However, since King-Webster and Rajkumar (1958) indicated that the gear was used year-round and targeted several species, only catches taken between November and June were assumed to comprise flyingfish. Further, it was assumed that fishing occurred five days per month from November to January (when seas are rough and movement of flyingfish onto the fishing ground is uncertain) and 20 days per month during the remaining months of the season. The average catch rate was 134 kg/day. This was assumed applicable to the peak season (February to July) and a catch rate of half this estimate was applied to the remaining months. Estimated total catch was (134*20*6) + (67*5*3) =16 080+1 005=17 085 kg or 17 085 tonnes.

1974–1984**:** Fabres (1986) provided estimates of flyingfish catch marketed through the Collector Vessel System implemented by the Government of Trinidad and Tobago.

1988–1997**:** Detailed records of landings and fishing effort are available for the drifting fishery, which targets flyingfish and associated large pelagics and is the major fishery of Tobago. The fishery uses mainly gillnets, but troll lines and banklines are also used to a lesser extent. Pandohee (1993) estimated total catches from the 1987–88 to 1991–92 fishing seasons at the three major beaches, Buccoo Point, Pigeon Point and Mount Irvine. The methodology involved application of raising factors to account for unrecorded fishing days at recorded landing sites, and boats at minor and unrecorded landing sites, as described for the artisanal multigear fleet in Trinidad between 1995 and 2001. Estimates of total catches were available for ten beaches (five recorded and five unrecorded sites) for the 1992–93 fishing season and the 1993–94 fishing season, in Pandohee (1994) and Mohammed (1996) respectively. Mohammed (1998) provided estimates of total catch at the Buccoo Point and Pigeon Point landing sites for the fishing seasons from 1994–95 to 1996–97. Traditionally, statistics for this fishery are presented for a fishing season which runs from November to June or July. Data were adjusted accordingly to represent catches for the calendar year. Estimates for the three most recent years were available for two landing sites only (Buccoo and Pigeon Point). These data were adjusted to account for catches at the other eight landing sites, assuming that the average ratio of the respective species catches at Buccoo Point and Pigeon Point (first site) and overall total species catch at the ten sites in 1993 and 1994 was the same for 1995 to 1997.

1998–2008**:** A data collection form was designed to capture data on monthly flyingfish throughput at major processing plants and the associated proportion of overall monthly catch of the species (Appendix I). During the period there were four major processing plants for flyingfish. However, two of these plants ceased operations within the last two to three years. Plant A provided data in the required format, for 2004 to 2008. The same annual throughput for 1998 to 2003 as that given for 2004 was assumed. Data for Plant B was provided by an official of the Tobago House of Assembly. This plant ceased operations in August 2005. Plant C provided data on flyingfish throughput in 2000 and 2003 to 2006. Flyingfish throughput for 2007 and 2008 was assumed the same as that given for 2006; while throughput for 2001 and 2002 was estimated by interpolation between 2000 and 2003 estimates, and throughput for 1998 and 1999 was assumed the same as that given for 2000. Plant D provided crude estimates of annual flyingfish throughput. This plant ceased operations at the end of the 2006/2007 season.

Estimated flyingfish landings (1957 to 2008)

The data indicate that flyingfish landings were greater between 1990 and 2004 than previous years (Figure 2). Over these years, landings ranged between 453 and 699 tonnes. Average annual landing from 1974 to 1988 was 138 tonnes. Landings appear to have declined considerably over the last three years (2005 to 2008), averaging 195 tonnes. This decline was due primarily to a shortage of labour in processing plants, lack of adequate blast freezing facilities to service these plants, and closure of two major plants.

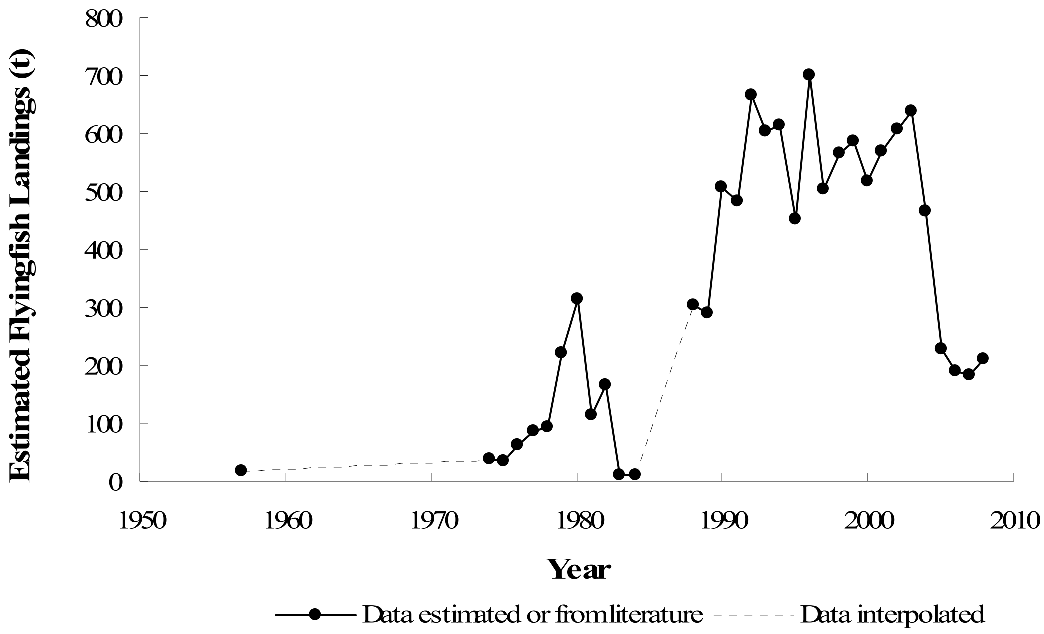


Figure 2. Estimated flyingfish landings in Tobago (1957 to 2008).

TABLE 1
Estimated annual flyingfish landings in Tobago (1957 to 2008)

Year	Estimated landings (tonnes)	Data source	Year	Estimated landings (tonnes)	Data source
1957	17	King-Webster (1957), King-Webster and Rajkumar (1958)	1983	10	Fabres (1988)
1958	18	Interpolation	1984	11	Fabres (1988)
1959	19	Interpolation	1985	84	Interpolation
1960	21	Interpolation	1986	157	Interpolation
1961	22	Interpolation	1987	229	Interpolation
1962	23	Interpolation	1988	302	Adjusted from Pandohee (1993) to account for non-enumerated landing sites
1963	24	Interpolation	1989	290	
1964	25	Interpolation	1990	507	
1965	26	Interpolation	1991	482	
1966	28	Interpolation	1992	664	
1967	29	Interpolation	1993	604	Adjusted from Pandohee (1994) to account for non-enumerated landing sites
1968	30	Interpolation	1994	615	Adjusted from Mohammed (1996) to account for non-enumerated landing sites
1969	31	Interpolation	1995	453	Adjusted from Mohammed (1998) to account for non-enumerated landing sites
1970	32	Interpolation	1996	699	
1971	33	Interpolation	1997	503	
1972	35	Interpolation	1998	566	Estimated from Processing Plant Data
1973	36	Interpolation	1999	585	
1974	37	Fabres (1988)	2000	517	
1975	35	Fabres (1988)	2001	570	
1976	61	Interpolation	2002	605	
1977	87	Fabres (1988)	2003	639	
1978	92	Fabres (1988)	2004	466	
1979	222	Fabres (1988)	2005	229	
1980	313	Fabres (1988)	2006	191	
1981	115	Fabres (1988)	2007	183	
1982	164	Fabres (1988)	2008	210	

Catch per unit effort

Details on catches from individual boat trips are available from 1988 to 2008 fishing seasons. The number of fishing trips recorded annually has declined from 1 283 in 1990 to less than 400 since 1998 (Figure 3). This decreased coverage of the drifting fishery is due to expansion of the data collection system to include other important fisheries without similar increases in financial and human resources. Average monthly catch per unit effort (CPUE) varies considerably (Figure 4). CPUE, standardized using a general linear model, shows high CPUE during the late 1990s but a decline thereafter, from 327 kg per trip in 2002 to 135 kg per trip in 2007 (Figure 5).

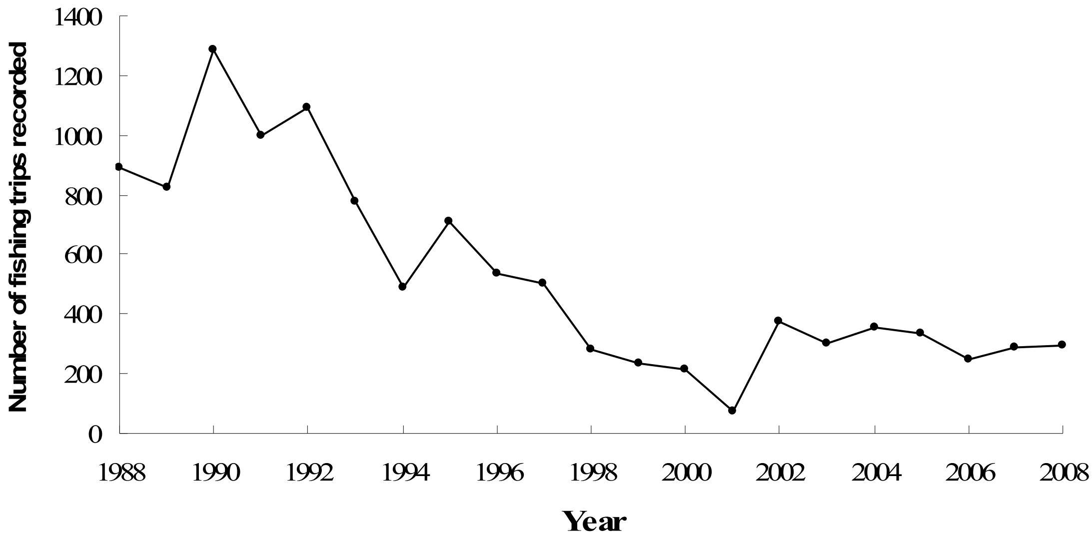


Figure 3. Number of fishing trips recorded for the drifting fishery in Tobago (1988 to 2008 fishing seasons).

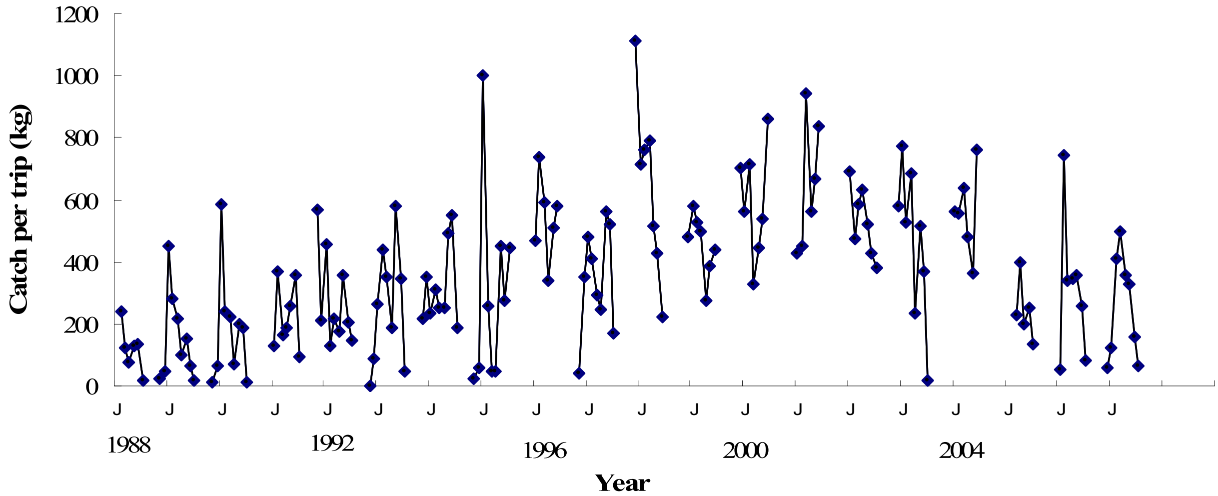


Figure 4. Monthly variability in flyingfish catch (kg) per trip (1988 to 2008).

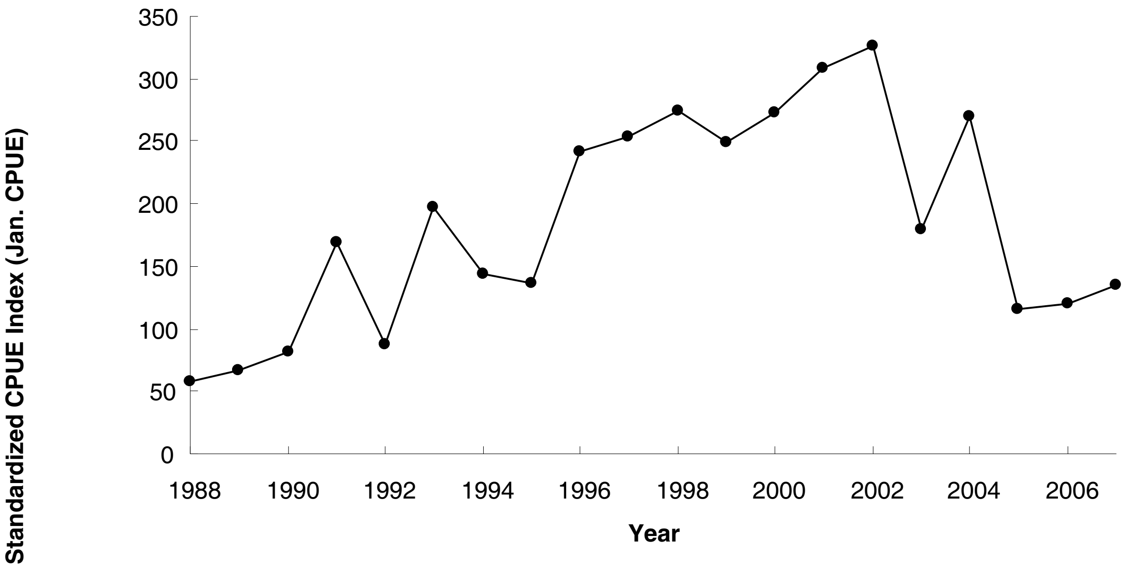


Figure 5. Standardized CPUE (kg per trip) for the flyingfish fishery in Tobago (1988 to 2007).

Data limitations and recommendations

The varying approaches to data collection and methods for estimating total landings introduce uncertainties in interpretation of the trends in estimated landings. Landings from 1988 to 1998, although estimated using a procedure to account for non-enumerated days (at recorded sites) and non-enumerated landing sites, are uncertain due to the assumption of a constant fleet structure and spatial distribution along the coast as that which existed in 1991. Although landings in the early season months (November and December) are usually low in comparison with other months, the definition of the year (i.e. whether calendar or fishing season) can also impact on the observed trends. Between 1988 and 1998 data are represented by fishing seasons (i.e. 1994 fishing season extends from November 1993 to July 1994), but it is not certain whether figures quoted in the literature or obtained from most of the processing plants are similarly grouped. This problem could easily be resolved if data are available monthly to facilitate the appropriate grouping.

The decline in coverage of the drifting fishery, whereby three major sites are enumerated eight days per month, decreases the utility of the data for estimating total landings. In addition, changes in activity on weekends and public holidays, as well as ice-boat (also called multipurpose fishing boats) catches, are not captured in the existing data collection system. There is an urgent need to review the current data collection system and methodology for estimating total landings from recorded data. Data from periodic boat census can be used to estimate landings of flyingfish, as well as other species from non-enumerated sites.

Flyingfish throughput data from processing plants was used to reconstruct total landings. The data acquired are difficult to interpret because of the assumptions taken to fill gaps and exclusion of data from smaller plants and cottage type industries which were not available. In addition the quantities of flyingfish sold locally were not accounted for. Information on the proportion of total landings that is processed can be used to estimate total landings from processing data if the total amount processed is known.

ParFish stock assessment interviews

ParFish is a rapid and participatory approach to stock assessment that assists fishers and other stakeholders to enter a cycle of learning, evaluation, management planning and implementation (Walmsley *et al*., 2005). Adaptive management is inherent in the approach as the impacts of management action are assessed and periodically evaluated to reformulate management plans and action. The approach incorporates traditional assessment methods, fishers' knowledge of stock status and behaviour, and their preference for outcomes of different management controls. It is suitable for the developing countries, where data are limited, fisheries are small to medium scale with spatially defined management units, and the policy directive supports stakeholder involvement in the management decision-making process.

For the Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, stock assessment interviews, consistent with the ParFish approach, were conducted in Tobago. The intention was not to conduct a ParFish assessment but rather to obtain information from experienced fishers from which priors on the unexploited biomass (assuming CPUE is a good indicator of stock abundance) and the population recovery rate could be obtained for the regional stock assessment model. It is noted that similar interviews were not conducted in other countries exploiting the resource.

In Tobago, stock assessment interviews, modified to capture information on flyingfish (Appendix II), were conducted with eight fishers operating in the drifting fishery. These fishers fished for between 27 and 45 years and all owned fishing boats. The number of days usually spent fishing each month was low, five to seven days, although one fisher indicated that he fished every day except for those days of unsuitable weather conditions. The estimates of current catch per trip ranged between 227 and 1 705 kg (Table 2). Although five of the respondents indicated that flyingfish CPUE has been declining over the last few years, this observation was not always consistent with their estimate of CPUE in the previous drifting season (2006/2007), i.e. CPUE in the previous season was lower than the CPUE in the current season according to four of the respondents. Two respondents indicated CPUE in the previous season that was higher than the current season. Fishers attributed the decline in CPUE to seismic activities of a foreign petrochemical company in the vicinity of the fishing ground and a reduction in available fish aggregation devices. Three of the respondents noted that CPUE had declined over the previous three to four years, but that it had increased again in the current season. Fishers' responses on the unexploited CPUE (as is expected of a virgin stock) varied considerably, and are likely indicative of their knowledge of interannual variability of the stock. The lower estimate of unexploited CPUE varied between 136 kg and 6 818 kg, while the higher estimate varied between 1 364 kg and 6 818 kg. Two respondents indicated similar estimates for both the low and high unexploited CPUE (1 818 kg and 6 818 kg). In five of the eight responses, the low CPUE estimate for the unexploited stock was less than the current CPUE, suggesting that fishers probably did not understand the line of questioning or were accounting for interannual stock variability in their responses. The recovery time for the current stock to replenish itself to historical levels (comparable to an unexploited stock) varied between 2 and 4.5 years.

TABLE 2
Selected responses of fishers to ParFish stock assessment interview questions

Fisher name	Years fishing	Last year CPUE (kg per trip)	Unexploited CPUE		Recovery period (years)	Current CPUE (kg per trip)
			Low (kg per trip)	High (kg per trip)		
A	30.0	1 136	1 818	1 818	1.5	909
B	30.0	1 136	1 136	3 182	4.5	1 250
C	34.0	1 136	455	2 500	2.5	1 364
D	28.0	1 136	227	1 364	3.0	1 364
E	45.0	0	909	2 727	3.8	1 705
F	35.0	0	136	3 636	2.0	1 364
G	45.0	682	6 818	6 818	4.5	909
H	27.0	795	1 136	1 364	2.3	227

REFERENCES

Fabres, B. 1986. The flyingfish fishery of Trinidad and Tobago. pp. 7–10. *In* Mahon, R., H. Oxenford and W. Hunte (eds.) Development strategies for flyingfish fisheries of the eastern Caribbean: Proceedings of an IDRC-Sponsored Workshop at the University of the West Indies. Bedford Institute of Oceanography, Nova Scotia, Canada, and Bellairs Research Institute of McGill University, St James: 148 pp.

Fisheries Division. 2007. A draft policy for the fisheries sector of Trinidad and Tobago. Fisheries Division, Ministry of Agriculture, Land and Marine Resources, Port of Spain, Trinidad and Tobago. 57p.

King-Webster, W.A. 1957. Fisheries Department report on the fisheries of Tobago. October, 1957. Fisheries Department, Port of Spain, Trinidad, Trinidad and Tobago: 24 pp.

King-Webster, W.A. & Rajkumar H. O. 1958. A preliminary survey of the fisheries of the island of Tobago. Caribbean Commission Central Secretariat: 19 pp.

Mohammed, E. 1996. 1993–1994: Reports on the drifting fishery of Tobago. Fisheries Division, Ministry of Agriculture, Land and Marine Resources, Port of Spain, Trinidad, Trinidad and Tobago: 105 pp.

Mohammed, E. 1998. 1994/95–1996/97: Reports on the drifting fishery of Tobago (Buccoo and Pigeon Point Landing Sites). Fisheries Division, Ministry of Agriculture, Land and Marine Resources, Port of Spain, Trinidad, Trinidad and Tobago: 224 pp.

Moore-Miggins and Company (Trinidad and Tobago) & Scales Consulting Ltd (United Kingdom). 2006. Report on the September 2006 Stakeholder Consultations. Submitted to the Fisheries Division based on the Agreement relating to Consultancy Services for the Expedition of the Revision and Finalization of the Draft Marine Fisheries Management Act and Drafting of Regulations for the Ministry of Agriculture, Land and Marine Resources. 51p.

Pandohee, E. 1993. 1987/88–1991/92 fishing seasons: Reports on the drifting fishery of Tobago. Fisheries Division, Ministry of Agriculture, Land and Marine Resources, Port of Spain, Trinidad, Trinidad and Tobago: 185 pp.

Pandohee, E. 1994. 1992–1993: Reports on the drifting fishery of Tobago. Fisheries Division, Ministry of Agriculture, Land and Marine Resources, Port of Spain, Trinidad, Trinidad and Tobago: 109 pp.

Potts, A C., Thomas A.D. & Nichols E. 2002. An economic and social assessment of the flyingfish (pelagic) fishery of Trinidad and Tobago, pp. 133-145. *In* FAO/Western Central Atlantic Fishery Commission. Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report* 670.

Samlalsingh, S., Mohammed E. & Caesar E. 2007. The flyingfish fishery of Trinidad and Tobago. Pp 33-45. *In* Oxenford, H.A., R. Mahon and W. Hunte (eds.). Biology and Management of Eastern Caribbean Flyingfish. Centre for Resource Management and Environmental Studies. University of the West Indies, Barbados. 267pp.

Walmsley, S.F., Howard C.A. & Medley P.A. 2005. Participatory Fisheries Stock Assessment (ParFish) Guidelines. London. Marine Resources Assessment Group Ltd. 166 p.

APPENDIX I

Tobago Processing Plant Data on Flyingfish Purchases/Receipts/Throughput

Processing Plant: (optional)
Weight Units (enter lbs or kgs):

Year	Month	Quantity	% TL	Year	Month	Quantity	% TL	Year	Month	Quantity	% TL
	Jan				Aug				Oct		
	Feb				Sep			**2000**	Nov		
	Mar			**2004**	Oct				Dec		
2008	Apr				Nov				Jan		
	May				Dec				Feb		
	Jun	Not available			Jan				Mar		
	Jul	Not available			Feb				Apr		
	Jan				Mar				May		
	Feb				Apr			**1999**	Jun		
	Mar				May				Jul		
	Apr			**2003**	Jun				Aug		
	May				Jul				Sep		
2007	Jun				Aug				Oct		
	Jul				Sep				Nov		
	Aug				Oct				Dec		
	Sep				Nov				Jan		
	Oct				Dec				Feb		
	Nov				Jan				Mar		
	Dec				Feb				Apr		
	Jan				Mar				May		
	Feb				Apr			**1998**	Jun		
	Mar				May				Jul		
	Apr			**2002**	Jun				Aug		
	May				Jul				Sep		
2006	Jun				Aug				Oct		
	Jul				Sep				Nov		
	Aug				Oct				Dec		
	Sep				Nov						
	Oct				Dec						
	Nov				Jan						
	Dec				Feb						
	Jan				Mar						
	Feb				Apr						
	Mar				May						
	Apr			**2001**	Jun						
	May				Jul						
2005	Jun				Aug						
	Jul				Sep						
	Aug				Oct						
	Sep				Nov						
	Oct				Dec						
	Nov				Jan						
	Dec				Feb						
	Jan				Mar						
	Feb				Apr						
	Mar			**2000**	May						
2004	Apr				Jun						
	May				Jul						
	Jun				Aug						
	Jul				Sep						

Quantity: amount of flyingfish purchased each month.

% TL: The percentage of overall monthly landings which is thought to be purchased by the particular processing plant.

____
Name of person completing form (optional)

Date ____________________________

Any questions? Please contact the Department of Marine Resources & Fisheries - 639 4354/1382 OR Fisheries Division - 623 8542

A collaborative effort beween the Fisheries Division & Department of Marine Affairs and Fisheries
Completed data sheets should be submitted to Mr Kenneth Caesar, Director, Department of Marine Affairs and Fisheries, TLH Building, Scarborough, Tobago; Fax: 639 4446; Email: fishmar@tstt.net.tt by **June 20, 2008**

APPENDIX II

ParFish Stock Assessment Interview Form (modified for the Drifting Fishery of Tobago)

Date		**Interviewer**	
Fisher Name		**Telephone**	
Fisher Role		**Pirogue/Multi-Purpose**	
		Vessel length (feet)	

Units

Units of effort (e.g. days fishing)	**Days Fishing (24 hours)**	
Units of catch (E.g. kg, numbers, baskets, etc.)	**Pounds of Flyingfish**	
Units of Time (e.g. Calendar month, Lunar month, year)	**Calendar Month**	

Stock Assessment Interview			
Effort and catch rates			
For how many years have you been fishing for flyingfish?			
In each month in the drifting season, how many *days* do you usually spend fishing for flyingfish?			
How many *days* did you actually go drifting for flyingfish last season (2006/2007)? (Consider any downtime due to bad weather, breakdown, etc.)			
Normally in the drifting season, how many *pounds of flyingfish* do you catch in one *day's fishing*? (Do **not** consider where catch is limited due to low demand of processors, etc.)			
Over the last few years during the drifting season, has your flyingfish catch rate been about the same, declining or increasing? (Remove any effects other than population size, e.g. effects due to changes in gear or fishing practices, demand of processors.)			
If the catch rate has been changing: In the last drifting season (2006/2007), normally how many *pounds of flyingfish* did you get in one *day's fishing*? (Verify that change is **not** due to demand of processors, change in gear or fishing practices, etc.)			
If you were to fish in a fresh ground (never fished before or like the old days), in the drifting season how many pounds of flyingfish do you think you would catch in one day? (Get an estimated **range**. Used to estimate unexploited stock.)	Min.		
	Max.		
If fishing were to stop tomorrow, how many months or years do you think it would take for the flyingfish stocks to recover fully? ….Or as close as possible to what it was before fishing started.			

PART IV

DRAFT SUBREGIONAL FISHERIES MANAGEMENT PLAN FOR FLYINGFISH IN THE EASTERN CARIBBEAN

Contents

	Page
PREFACE	**55**
GUIDING PRINCIPLES	**56**
Mission	**56**
Code of Conduct	56
VISION OF THE FUTURE	**56**
LEGAL CONTEXT	**57**
International law and agreements	57
Regional and bilateral arrangements	57
GEOGRAPHY OF THE REGION	**58**
Physical geography	58
Political geography	61
Demography and economy	64
BIOLOGY AND ECOLOGY OF FLYINGFISH	**64**
Description and distribution of the species	65
Age, growth and longevity	65
Reproductive characteristics	66
Mortality	66
Recruitment	67
Species interactions	67
Critical habitat	67
MANAGEMENT UNIT	**68**
FISHERY CHARACTERISTICS	**68**
Development	68
Social and cultural importance	69
Contribution to economy	70
Fleets and interactions	70
Catch and effort	72
Gear and methods	74
Policy and legislation	74
Safety	75
Insurance and credit facilities	75
Post-harvest sector	75
STATUS OF THE FISHERIES	**76**
State of the stock	76
Issues and constraints	77
Opportunities	77
MANAGEMENT OBJECTIVES AND INDICATORS	**78**
Reference points	78
Data and monitoring requirements	79
CONTROLS	**79**
Output controls	79
Input controls	80
IMPLEMENTATION PLAN	**82**
Institutional and legal arrangements	82
Co-management	82
Time frame	82
Monitoring, control and surveillance	82
Data collection, sharing and data analysis	82
Financing	82
Research	82
REFERENCES	**84**

PREFACE

This Draft Subregional Fisheries Management Plan for Flyingfish in the Eastern Caribbean represents an amended version of the preliminary draft (Oxenford, 2002) produced intersessionally following the outline proposed by participants at the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean in Barbados, January 2001. The preliminary draft was reviewed intersessionally and discussed in detail by participants at the Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean in Tobago, July 2008. The deliberations and suggested amendments are recorded in the Third Meeting Report Part 1 (FAO, 2009).

This finalized draft is intended for presentation to the eastern Caribbean governments. It is further recognized that this fisheries management plan will remain a dynamic document and that further updating of the information contained herein, and the assessment and management advice will be undertaken by the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean over time, as appropriate.

The material is drawn from, and in some cases extracted directly from, a number of technical documents, the most significant references are given here. A full list of cited references is provided at the end of the document.

Barbados Fisheries Division. 2001. Barbados Fisheries Management Plan 2001–2003. Fisheries Division, Ministry of Agriculture and Rural Development, Government of Barbados, 72pp.

Barbados Fisheries Division. 2004. Barbados Fisheries Management Plan 2004–2006. Schemes for the management of fisheries in the waters of Barbados. Fisheries Division, Ministry of Agriculture and Rural Development, Government of Barbados, 67pp.

FAO. 2002. Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. *FAO Fisheries Report*. No. 670. 155 pp.

Mahon, R. 1993. Lesser Antilles. pp. 1–98, *in*: FAO (ed). Marine fishery resources of the Antilles: Lesser Antilles, Puerto Rico and Hispaniola, Jamaica, Cuba. *FAO Fisheries Technical Paper.* No. 326.

Mahon, R. 1996. Fisheries of small island states and their oceanographic research and information needs. Pp. 298–322. *In* Maul, G.A. (ed). Small islands: marine science and sustainable development. Coastal and Estuarine Studies 51, American Geophysical Union, Washington.

Maul, G.A. 1993. Climate change in the Intra-Americas Sea. E. Arnold, London, 389pp.

Oxenford, H.A., Mahon R. & Hunte W. 1993. The Eastern Caribbean Flyingfish Project. OECS Fishery Report 9, OECS Fishery Unit, Kingstown, St. Vincent, 171 pp.

Oxenford, H.A., Mahon R. and Hunte W. (eds). 2007. Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados. 268pp.

GUIDING PRINCIPLES

Mission

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

Code of Conduct

The FAO 1995 Code of Conduct for Responsible Fisheries shall be the guide to this Draft Subregional Fisheries Management Plan. The Code, which has a position of prominence among international fisheries instruments, promotes the adoption of practices for the sustainable use, management, development and conservation of all fisheries and aquaculture through the voluntary compliance of governments, fishing industries, non-governmental organizations and other entities associated with fisheries. Article 6 of the Code sets out general principles that are summarized below.

The guiding principles include, but are not limited to, the following:

- maintain biodiversity and use ecosystem approaches to management;
- manage fishing capacity and fishing methods to facilitate resource sustainability;
- engage in precautionary approaches to sustainable use, management and exploitation;
- establish effective mechanisms for monitoring, control and surveillance;
- collect and provide data including sharing, pooling and information exchange;
- ensure that fisheries decision-making processes are transparent and that all stakeholders have the opportunity to participate;
- cooperate with States in order to prevent disputes or resolve them in a peaceful manner;
- protect and rehabilitate critical fisheries habitats and the environment generally;
- use post-harvest practices that maintain nutritional value and quality of products;
- include fisheries interests in all aspects of management planning and development;
- conduct trade in fish and fishery products according to applicable agreements;
- promote awareness of responsible fishing through education and training;
- ensure safe, healthy and fair working and living conditions for fishery workers;
- recognize the contribution of small-scale fisheries to employment, income and food security;
- promote aquaculture as a means for diversification of income and diet; and
- encourage aquaculture as a means to promote diversification of income and diet.

VISION OF THE FUTURE

It is envisaged that shared fishery resources in the eastern Caribbean will be collaboratively managed to give fair access to and distribution of benefits to all people in the eastern Caribbean region.

The harvest sector across the region should comprise well-trained full-time and part-time fishers with capital investment in the fishery and a commitment to the use of responsible fishing practices. This sector should be supported by active fisherfolk organizations with effective links among fisherfolk organizations of other eastern Caribbean countries and to their own governments. Access to reasonably priced fishing equipment and supplies and to a stable market should be assured. The post-harvesting sector should be further developed to ensure high-quality fish and fish products, prevent wastage, promote greater distribution of profits with the use of value-added (processed) products, and better distribution to all sectors of the local public (through road distribution, supermarkets, mini-marts, restaurants, etc.) and export markets.

LEGAL CONTEXT

International law and agreements

International instruments of direct relevance to fisheries include the following legally binding treaties and agreements:

- United Nations Convention on the Law of the Sea (UNCLOS 1982), which came into force in 1994.
- Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (i.e. 1995 UN Fish Stocks Agreement), which came into force in 2001.
- Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (i.e. 1993 FAO Compliance Agreement), which came into force in 2003.

Other significant instruments include the following non-binding declarations/codes:

- 1992 UN Agenda 21: Programme of Action for Sustainable Development, Chapter 17: Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas and coastal areas, and the protection, rational use and development of their living resources. This action plan was agreed to at the 1992 United Nations Conference on Environment and Development (UNCED).
- 1995 FAO Code of Conduct for Responsible Fisheries, which although largely voluntary, has certain provisions that are already, or may become, legally binding. The code covers all aspects of fisheries, including harvest, fishing operations, management, post-harvest, trade and research, and gives particular attention to small island developing states (SIDS) and small-scale fisheries.
- 2001 Reykjavik Declaration, representing a voluntary commitment to adopt an ecosystem-based approach to fisheries management.
- 2005 Rome Declaration on IUU Fishing, recognizing the impacts of IUU fishing on small-scale fisheries, and calling for improved national and regional monitoring, control and surveillance of unauthorized, illegal fishing and implementation of severe punitive measures.

Also relevant to international considerations are the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the 1992 Convention on Biological Diversity (CBD), the 1973/78 International Convention on the Prevention of Marine Pollution from Ships (MARPOL), the 1994 SIDS Plan of Action, and the 2002 World Summit on Sustainable Development Johannesburg Plan of Implementation.

Membership to these conventions and treaties among the eastern Caribbean states is shown in Table 1.

Regional and bilateral arrangements

The Caribbean Community (CARICOM), established through the Treaty of Chaguaramas in 1973, and currently being amended by a series of Protocols, will become of increasing relevance to fisheries management. The Caribbean Regional Fisheries Mechanism (CRFM) is intended to implement Protocol V on agricultural policy as it relates to fisheries and is currently working towards the adoption of a common fisheries policy among CARICOM states. The other protocols concerning the movement of people and capital, trade policy, subsidies and other elements of governance in the move towards a Caribbean Single Market and Economy (CSME) will change the fisheries management environment in the region and its interfaces with the global fisheries regime.

Also of particular relevance in the region is the 1983 Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (i.e. the Cartagena Convention), which entered into force in 1986, and the associated 1990 Protocol for Specially Protected Areas and Wildlife (SPAW), which entered into force in 2000. Membership to these is also shown in Table 1.

TABLE 1
Membership to international and regional conventions and treaties of relevance to fisheries (as of October 2009)

Country	UNCLOS III	UN Fish Stocks Agreement	FAO Compliance Agreement	CITES	CBD	MARPOL	Cartagena Convention	SPAW Protocol
Barbados	Y	Y	Y	Y	Y	Y	Y	Y
Dominica	Y	N	N	Y	Y	Y	Y	N
Grenada	Y	N	N	Y	Y	N	Y	N
Martinique (France)	Y	Y	Y	Y	Y	Y	Y	Y
Saint Lucia	Y	Y	N	Y	Y	Y	Y	Y
Saint Vincent and the Grenadines	Y	N	N	Y	Y	Y	Y	Y
Trinidad and Tobago	Y	Y	N	Y	Y	Y	Y	Y

There are currently no valid regional or bilateral agreements related to the harvest of flyingfish, although negotiations are ongoing towards another fishing agreement between Barbados and Trinidad and Tobago.

In relation to fishing, and ocean management generally, where maritime boundaries are not yet delimited, countries in the eastern Caribbean should be encouraged to engage in marine boundary delimitation negotiations. This will determine the actual size of the marine jurisdiction or Exclusive Economic Zones (EEZs) within the subregion. Without fisheries management agreements, which may include fisheries access agreements, it is unlikely that either the conservation or development of fisheries in this region will be successful or sustainable given the close geographical proximity and sharing of fisheries resources.

GEOGRAPHY OF THE REGION

Physical geography

Hydrography, currents and bathymetry

The eastern Caribbean is characterized by a series of volcanic islands forming the Lesser Antilles island arc. This includes Grenada, Saint Vincent and the Grenadines, Saint Lucia, Martinique and Dominica. These islands typically have high relief and very limited island shelf area. There is a deep (6 000 metres) trough to the east of the islands known as the Tobago Trough. Barbados, which is not volcanic, sits to the east of this trough on sedimentary material, has low relief, is capped by coral limestone, and also has very limited shelf area. Trinidad and Tobago on the other hand sit on a relatively wide continental shelf associated with the South American mainland (see Table 2 for estimates of shelf area).

Circulation patterns in the Caribbean are complex and governed by fresh-water runoff, topography, sea-surface temperature, wind stress and primarily by the North Equatorial Current. Atlantic water enters the Caribbean through the passages between the eastern Caribbean islands, forming the westward flowing Caribbean Current (see Figure 1). Atlantic water also flows north westwards up the

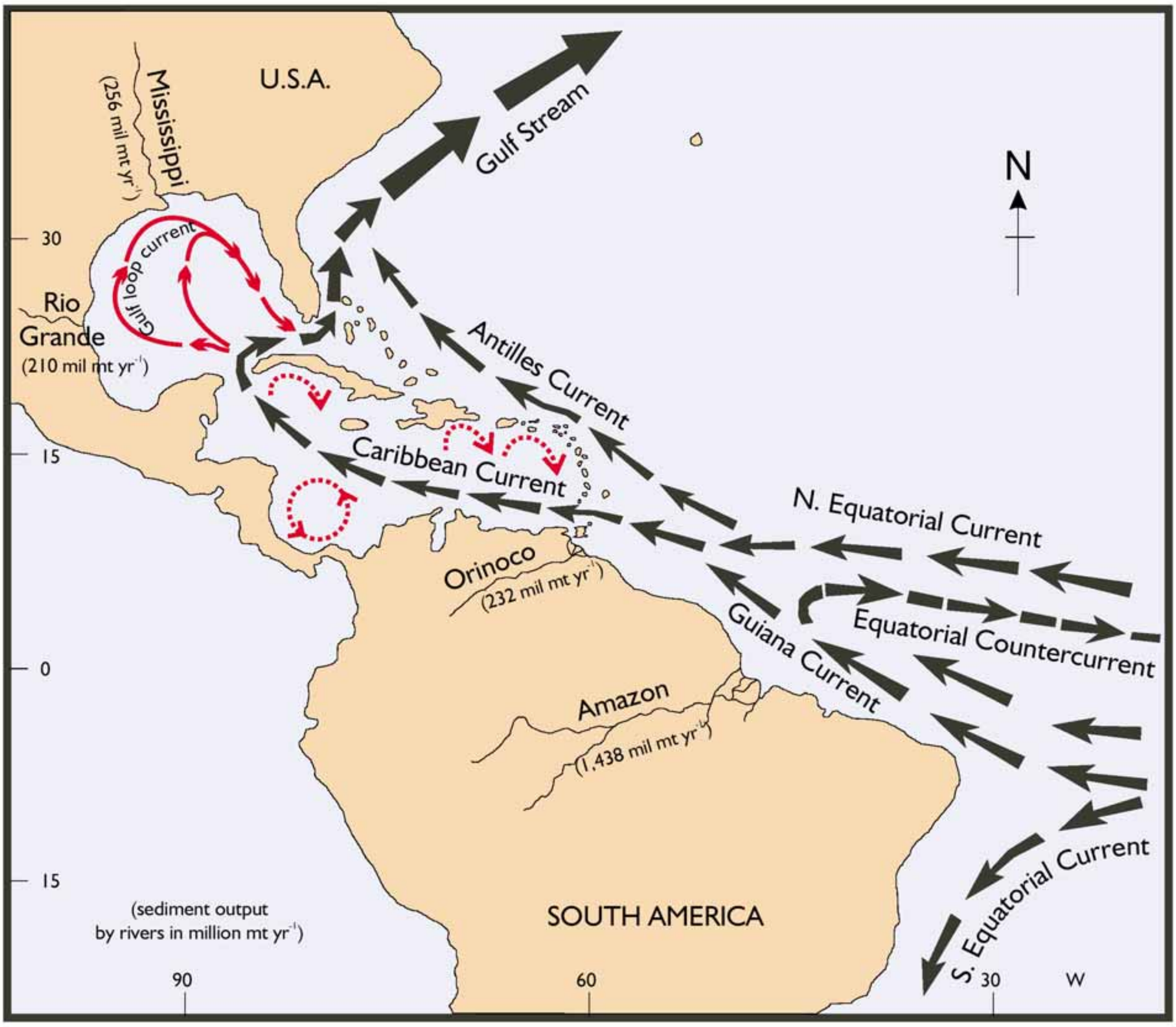


Figure 1. Major surface currents and river outflows affecting the wider Caribbean. Adapted from Oxenford (1985).

island chain via the Antilles Current. These two currents ultimately remerge to form the Gulf Stream. However, the relative strengths of the currents and thus the water supplying the North Equatorial Current varies seasonally as a result of the annual displacement of the Intertropical Convergence Zone (ITCZ). The ITCZ moves northwards to about 10 ^{o}N by August–September and southwards to just south of the equator by January–March.

During summer through winter the North Equatorial Current is supplied by oligotropic (low nutrient) oceanic waters of the North Atlantic. However, from around February to June, when the North Equatorial Countercurrent weakens, the Guiana Current, flowing northwestwards along the South American mainland and fed by the South Atlantic Equatorial Current, brings eutrophic (high nutrient) waters influenced by the outflow of the Amazon and Orinoco Rivers to join the North Equatorial

Current and enter the Caribbean via the eastern Caribbean island passages. As such, the source and the primary productivity of the waters around the eastern Caribbean are variable with the season.

The influence of South American river outflow on the eastern Caribbean varies seasonally and among islands. Trinidad is heavily influenced by Orinoco outflow all year-round. Tobago, Grenada, and the Grenadine Islands are influenced by the Orinoco outflow to a lesser extent, and seasonally during the rainy period. The other eastern Caribbean islands are not usually affected by this water mass. However, Amazon water, which sheds from the coast of Brazil in mesoscale eddies between October and March, is brought into the Caribbean via the Guiana Current, and tends to influence the eastern Caribbean islands as far north as Saint Lucia. These approximate boundaries of influence are illustrated in the diagrammatic map (Mahon 1996; Figure 2).

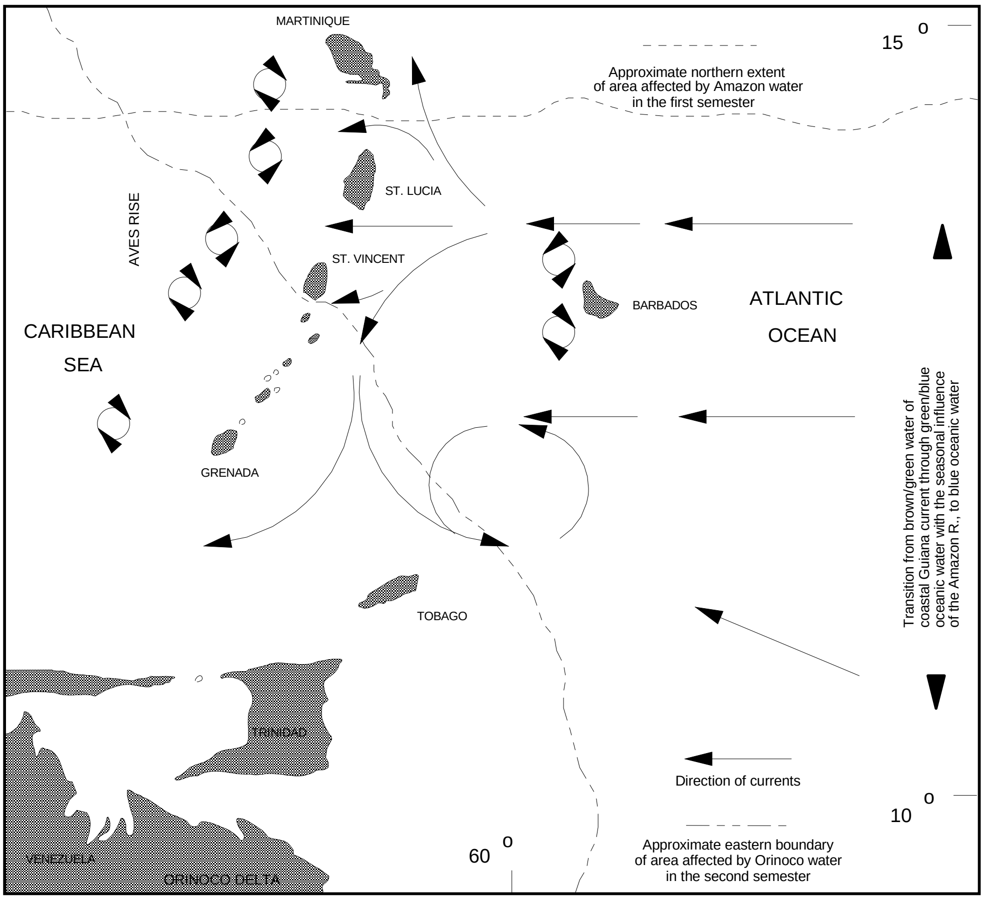


Figure 2. A synthesis of physical oceanographic characteristics of possible significance to fisheries in the eastern Caribbean. From Mahon (1996).

Mesoscale current patterns in the eastern Caribbean are also extremely complex but not well documented. A series of mesoscale eddies, which eventually shed, are formed downstream of the islands as the Caribbean Current flows westwards. There is also some evidence for periods of current reversal and larger scale eddies in the lee of Barbados and Tobago (Mahon, 1996).

Climate and weather

The eastern Caribbean has a typical tropical maritime climate with relatively constant air temperatures throughout the year, and a diurnal range of between 24 and 34 ^{o}C. The climate of the region does however have a seasonal cycle dominated by the displacement of the ITCZ. When the ITCZ is displaced to the south (December–April), the region is influenced by strong steady Northeast Trade Winds, clear sky, low rainfall, high atmospheric pressure and strong surface water currents. When the ITCZ is displaced to the north (June–October), the region is influenced by low wind speed, high cloud cover, high rainfall, low atmospheric pressure and low current speeds. It is during this time that the region is also affected by tropical storms and hurricanes. Tropical storms generally follow the path of the major surface currents of the Caribbean and Gulf Stream System after spawning in the central Atlantic. Most tropical storms develop during the summer, when surface water temperatures are highest, with September being the month of greatest activity. Hurricanes generate coastal sea level rise as high as 6 metres, and storm waves that in coastal areas may have wave heights as great as 15 metres at the time of breaking (Maul, 1993).

Political geography

The eastern Caribbean (Lesser Antilles) subregion is one of the most compact multinational archipelagos in the world. The eastern Caribbean flyingfish (*Hirundichthys affinis*) stock is shared by seven different countries (Barbados, Dominica, Grenada, Martinique (France), Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago), each with a national democratic government (see Table 2 for details of governance). With the exception of Martinique, which remains a department of France, the other islands are all independent, most belonging to the commonwealth (Table 2). Furthermore, membership to regional and international organizations with responsibility for fisheries management and development in the wider Caribbean varies among the islands (Table 3).

All of the eastern Caribbean countries have declared 200 nmi EEZs, although boundaries between some neighbouring countries are still to be negotiated. Grenada, Saint Vincent and the Grenadines, and Trinidad and Tobago have also been granted Archipelagic Status under UNCLOS (Figure 3.)

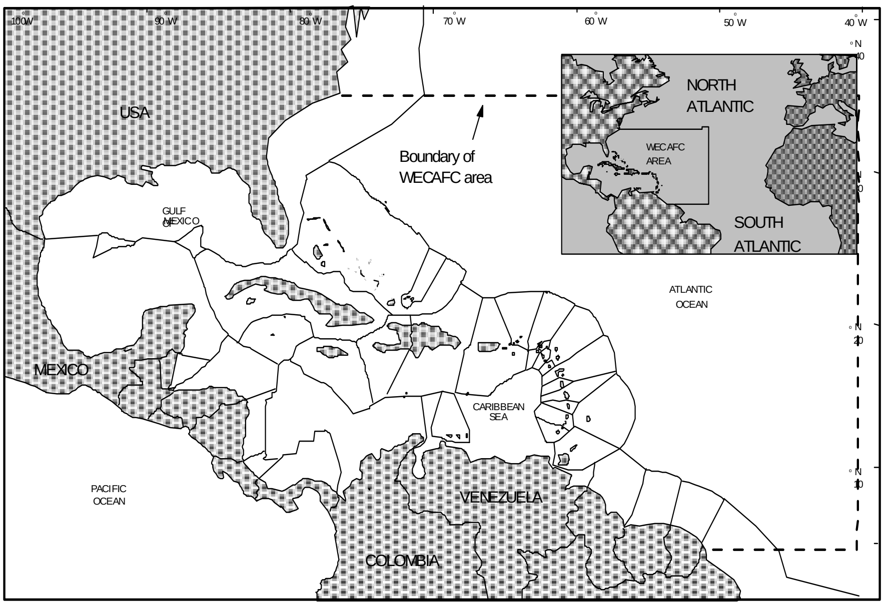


Figure 3. Map of wider Caribbean showing potential EEZs. From Barbados Fisheries Management Plan (2001).

TABLE 2. **Country profiles for the eastern Caribbean islands providing basic statistics for geography, governance, demography and economy. Primary data source: CIA (2009) The World Factbook. Other data sources include: [1] Mahon (1993); [2] International Labour Organization Caribbean Office (2009) @ www.ilocarib.org.tt/portal/index.php; [3] FAO (1993) Status of Caribbean Aquaculture; [4] FAO (2008) Yearbook.**

	Barbados	**Dominica**	**Grenada**	**Martinique**	**Saint Lucia**	**Saint Vincent and the Grenadines**	**Trinidad and Tobago**
Geography							
Location	13°10'N 59°35'W	15°30'N 61°20'W	12°00'N 61°45'W	14°30'N 61°00'W	14°00'N 61°00'W	13°15'N 61°15'W	10°30'N 61°15'W
Land area (km^2)	432	754	344	1 100	616	388	5 128
Coastline (km)	92	148	121	350	158	150	362
Shelf area (km^2)[1]	320	303	1 595	1 013	522	1 800	?
Approx. EEZ area (km^2)[1]	48 800	10 200	7 700	13 000	4 700	9 500	80 000
Maritime claims (nmi)	EEZ 200 Territorial sea 12	EEZ 200 Contig. zone 24 Territorial sea 12	EEZ 200 Territorial sea 12	EEZ 200 Territorial sea 12	EEZ 200 Contig. Zone 24 Territorial sea 12	EEZ 200 Contig. Zone 24 Territorial sea 12	EEZ 200 Contig. Zone 24 Territorial sea 12
Climate (rainy season)	Tropical (June–October)	Tropical (June–October)	Tropical (June–October)	Tropical (June–October)	Tropical (May–August)	Tropical (May–December)	Tropical (June–December)
Terrain	Coralline and relatively flat	Volcanic and mountainous	Volcanic and mountainous	Volcanic and mountainous	Volcanic and mountainous	Volcanic and mountainous	Plains and low mountains
Elevation (m)	337	1 447	840	1 397	950	1 234	940
Governance							
Type	Parliamentary democracy, Independent Sovereign State in Commonwealth	Parliamentary democracy, Republic in Commonwealth	Parliamentary democracy, Independent Sovereign State in Commonwealth	Parliamentary democracy Overseas department of France	Parliamentary democracy, Independent Sovereign State in Commonwealth	Parliamentary democracy, Independent Sovereign State in Commonwealth	Parliamentary democracy
Capital	Bridgetown	Roseau	St George's	Fort de France	Castries	Kingstown	Port of Spain
Administrative divisions	11 parishes	10 parishes	6 parishes, 1 dependency	0	11 quarters	6 parishes	8 counties, 3 municipalities, 1 ward
Independence	30 Nov. 1966	3 Nov. 1978	7 Feb. 1974	None	22 Feb. 1979	27 Oct. 1979	31 Aug. 1962
Constitution	30 Nov. 1966	3 Nov. 1978	19 Dec. 1973	28 Sept. 1958	22 Feb. 1979	27 Oct. 1979	1 Aug. 1976
Legal system	English common law	English common law	English common law	French legal system	English common law	English common law	English common law
Elections	House of Assembly (15 Jan. 2008)	House of Assembly (1 Oct. 2003)	House of Represent. (8 July 2008)	Regional Assembly (6 May 2007)	House of Assembly (11 Dec. 2006)	House of Assembly (7 Dec. 2005)	House of Representatives Tobago House of Assem. (11 Feb. 2008)
Chief of State (Represented by)	Queen Elizabeth II (Governor General)	President	Queen Elizabeth II (Governor General)	President	Queen Elizabeth II (Governor General)	Queen Elizabeth II (Governor General)	President
Head of Government (in power since)	Prime Minister David Thompson (16 Jan. 2008)	Prime Minister Roosevelt Skerrit (8 Jan. 2004)	Prime Minister Tillman Thomas (9 July 2008)	Prime Minister Francois Fillon (17 Mar. 2007)	Prime Minister Stephenson King (9 Sept. 2007)	Prime Minister Ralph Gonsalves (29 Mar. 2001)	Prime Minister Patrick Manning (24 Dec. 2001)

TABLE 2. **Continued**

	Barbados	Dominica	Grenada	Martinique	Saint Lucia	Saint Vincent and the Grenadines	Trinidad and Tobago
Demography							
Population (year)	284 589 (2009 est.)	72 660 (2009 est.)	90 739 (2009 est.)	425 966 (2003 est.)	160,267 (2009 est.)	104 574 (2009 est.)	1 229 953 (2009 est.)
Population growth (annual %)	0.383 (2009 est.)	0.208 (2009 est.)	0.468 (2009 est.)	0.85 (2003)	0.416 (2009 est.)	- 0.344 (2009 est.)	- 0.102 (2009 est.)
Language	English	English French patois	English	French Creole patois	English French patois	English	English Hindi, French, Spanish, Chinese
Literacy (% over 15 yr)	99.7	94	96	93	90.1	96	98.6
Ethnicity	Black 90% Asian/mixed 6% White 4%	Black 86.8% Amerindian 2.9% White 0.8%	Black 82% Mixed 18% Amerindian (trace)	Black/mixed 90% White 5% Other <5%	Black 82.5% Mixed 11.9% East Indian 2.4% Other 3.1%	Black 66% Mixed 19% East Indian 6% Amerindian 2% European 4% Other 3%	Black 37.5% Indian 40% Mixed 20.5% Other 2%
Labour force[2] Male[2] Female[2] Fishers[3] Other fishery related[3]	132 200 (2008) 68 700 63 500 2 200 3 800	33 420 (1997) 18 120 15 300 1 500 (1983) ?	41 015 (1998) 23 171 17 844 1 500 (1991) 120	126 900 (2008) 62 500 64 400 ? ?	62 265 (2004) 34 838 27 428 2 500 (1983) ?	58 000 (2008 est.) 35 000 24 000 2 000 (1983) 2 500	597 600 (2008) 353 500 245 900 7 300 (1985) 4 400
Unemployment rate[2] (%) Males[2] Females[2]	8.1 (2008) 6.8 9.4	11.0 (2001) 11.9 9.5	? ? ?	21.5 (2008) 19.0 23.8	21 (2004) 17.5 25	22 (1997) ? ?	4.6 (2008) 3.5 6.2
Annual per capita fish consumption (kg)[4] (Average 2003–2005)	36.5	30.2	38.1	15.4	36.3	15.0	16.9
Economy							
Currency (exchange US$) (equivalency to 1 US$)	Barbados dollar (2 fixed)	Eastern Caribbean dollar (2.7 fixed)	Eastern Caribbean dollar (2.7 fixed)	Euro (0.68 floating)	Eastern Caribbean dollar (2.7 fixed)	Eastern Caribbean dollar (2.7 fixed)	Trinidad and Tobago dollar (6.29 floating)
GDP (purchasing power parity in billions US$)	5.425 (2008 est.)	0.720 (2008 est.)	1.161 (2008 est.)	11.250 (2006)[2]	1.778 (2008 est.)	1.070 (2008 est.)	29.010 (2008 est.)
Per capita GDP (purchasing power parity in US$)	19,100 (2008 est.)	9,900 (2008 est.)	12,900 (2000)	28,014 (2006) [2]	11,100 (2008 est.)	10.200 (2008 est.)	23,600 (2008 est.)
External public debt (millions US$)[2]	668 (2003)	213 (2004)	347 (2004)	?	257 (2004)	223 (2004)	3,302 (2008 est.)
Main sectors (% GDP)	Service/tourism (78) Industry (16) Agriculture/fish (6) (2000 est.)	Agriculture/fish (17.7) Ind./commerce (32.8) Services (49.5) (2004 est.)	Services/tourism (76.6) Light industry (18) Agriculture/fish (5.4) (2003)	Services/tourism (83) Industry (11) Agriculture/fish (5) (1997)	Services (80) Industry (15) Agriculture/fish (5) (2005 est.)	Services (64) Agriculture/fish (10) Industry (26) (2001 est.)	Services (37.2) Industry (62.3) Agriculture/fish (0.5) (2008 est.)

TABLE 3. **Membership of eastern Caribbean islands to regional and international organizations with responsibility for fisheries management and development**

Country	OECS	WECAFC Lesser Antilles Committee	WECAFC	CARICOM	CARIFORUM	ICCAT	ACS
Barbados	N	Y	Y	Y	Y	Y	Y
Dominica	Y	Y	Y	Y	Y	N	Y
Grenada	Y	Y	Y	Y	Y	N	Y
Martinique (Department of France)	N	Y	Y	N	N	Y	Y
Saint Lucia	Y	Y	Y	Y	Y	N	Y
Saint Vincent and the Grenadines	Y	Y	Y	Y	Y	Y	Y
Trinidad and Tobago	N	N	Y	Y	Y	Y	Y

Note: OECS = Organisation of Eastern Caribbean States; WECAFC = Western Central Atlantic Fishery Commission; CARICOM = Caribbean Community; CARIFORUM = Caribbean Forum; ICCAT = International Commission for the Conservation of Atlantic Tunas; ACS = Association of Caribbean States;

Demography and economy

The islands of the eastern Caribbean are diverse in their demographic and economic characteristics as illustrated by the summary of key demographic indicators given in Table 2.

BIOLOGY AND ECOLOGY OF FLYINGFISH

Most of the information presented in this section is drawn from the research conducted by the International Development Research Centre/University of the West Indies/McGill University Eastern Caribbean Flyingfish Project (ECFFP) (1987–1993) in collaboration with the eastern Caribbean Fishery Departments of Barbados, Dominica, Grenada, Martinique, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago. Subsequent postgraduate research at the University of the West Indies has further informed the genetic population structure of the fourwing flyingfish in the central western Atlantic. This body of research is widely published in the scientific literature, but appears under one cover with synopses of the biological characteristics and management options for the fourwing flyingfish in Oxenford *et al.* (2007a).

Other substantive ECFFP documents include the Proceedings of the Project Development Workshop in 1985 (Mahon *et al.,* 1986); and the Organisation of Eastern Caribbean States Fishery Report (OECS) 9 (Oxenford *et al.,* 1993), which contains the Proceedings of the Interim and Final Project Workshops of 1987 and 1992, the two Flyingfish Research Cruise Reports of 1988 and 1989, and the six project News Bulletins published from May 1987 to January 1991.

Other research efforts that have focused on the biology and assessment of the eastern Caribbean fourwing flyingfish include some early studies by Hall (1955), Lewis *et al.* (1962) and Storey (1983), a preliminary stock assessment for the flyingfish fishery of Tobago conducted in 1991 under a United Nations Development Programme/FAO Project for the Establishment of Data Collection Systems and Assessment of the Fisheries Resources (Samlalsingh and Pandohee, 1992), and various review papers and national reports produced under the Small Coastal Pelagics and Flyingfish Sub-project of the

CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) (e.g. CFRAMP, 1996) and the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean (FAO, 1999, 2002, 2009).

Description and distribution of the species

Although around 13 species of flyingfish (Exocoetidae) occur in the eastern Caribbean region, only three species (*Hirundichthys affinis*, *Cypselurus cyanopterus* and *Parexocoetus brachypterus*) are known to be exploited. However, the target species of the offshore flyingfish fisheries of the eastern Caribbean (accounting for ~ 99 percent of all flyingfish landed) is the fourwing flyingfish (*Hirundichthys affinis*). *H. affinis* is a relatively small (maximum length is around 25 cm standard length; mean size taken by the fisheries is around 20–22 cm standard length) epipelagic species, distributed throughout the western tropical Atlantic (Figure 4) where it supports important commercial fisheries seasonally in the eastern Caribbean, Curaçao and off northeast Brazil (Parin, 2002). *H. affinis* is also reported from the eastern tropical Atlantic (Parin, 2002).

H. affinis is seasonally available to the fishing gear (November to July), and is patchily distributed across the eastern Caribbean. A tagging study has demonstrated that individuals move freely between the islands of the eastern Caribbean (Oxenford, 1994). Results from a flyingfish abundance survey cruise conducted in the eastern Caribbean in 1988 suggest that *H. affinis* is likely to be available in commercially viable quantities beyond the present range of local fishing fleets (Oxenford *et al.,* 1995).

Figure 4. Distribution of the fourwing flyingfish, *Hirundichthys affinis*, in the Western Central Atlantic, after Parin (2002).

Age, growth and longevity

H. affinis is a short-lived, essentially annual species with a maximum age of around 18 months (Campana *et al.,* 1993). *H. affinis* grows relatively fast when immature, reaching around 19 cm fork length (FL) in the first six months. Thereafter, growth rate is slow, with fish reaching around 22.5 cm FL at age one year and a maximum size of around 23 cm FL at 18 months (Oxenford *et al.,* 1994).

Direct aging through counting daily growth checks is relatively straightforward in juvenile specimens (up to 150 days) and has been validated through laboratory rearing (Oxenford *et al.,* 1994), but becomes problematic as growth rate slows down markedly as fish mature. Confirmation of longevity required radio-chemical dating of adult otolith cores (Campana *et al.,* 1993).

Best estimates of standard von Bertalanffy growth parameters for *H. affinis* based on validated size-at-age and longevity data are: L_4 = 24.5 cm FL, k = 0.01 (daily basis), t_0 = 2.85 days (Oxenford *et al.,* 1994)[1,2].

Reproductive characteristics

H. affinis may reach first maturity as small as 18.0 cm FL (around five months of age). The majority of fish are mature by 20.3 cm FL (around seven months of age) (Storey, 1983; Khokiattiwong *et al.,* 2000)[3]. They have relatively high gonosomatic indices (GSI) – GSI values of around 11.5 percent for females and 6.5 percent for males – and are batch spawners, with females laying around 7 000 relatively large eggs per batch (Storey, 1983; Khokiattiwong *et al.,* 2000). Individual fish are believed to spawn several times within the November to July spawning season. Furthermore, there appear to be two peaks in spawning activity during the spawning season, with a minor peak from November to January and a major one in April/May. This tends to be reflected in higher catches by the commercial fisheries at these times, and results from the fact that the fishing gear and methods target spawning fish (Hunte *et al.,* 2007).

Eggs are non-buoyant and highly adhesive, and are spawned on floating materials including natural flotsam and the fish aggregation devices and gillnets used to catch adult flyingfish. The scarcity of flotsam in the eastern Caribbean may be constraining flyingfish population size, or flyingfish may alternatively be using submerged spawning substrates. This issue needs further investigation and may reveal preferred spawning areas for this species (Hunte *et al.,* 2007).

Mortality

The average life span for *H. affinis* is around one year (maximum 18 months), so mortality rates must be high.

Several crude estimates are available for instantaneous natural mortality (M) on an annual basis, using empirical formulae after Pauly (1980) and Alagaraja (1984) (e.g. M = 4.4, Oxenford *et al.,* 1993, Oxenford *et al.,* 2007b; M = 1.8 to 3.1, Samlalsingh and Pandohee, 1992), which translate to actual natural mortality rates of somewhere between 83.5 percent and 98.8 percent of the population dying per year.

A crude catch curve estimate of instantaneous total mortality (Z = 5.8) on an annual basis is reported by Samlalsingh and Pandohee (1992), translating to an actual mortality of 99.7 percent of the population per year. This parameter is equivalent to the production/biomass ratio and was used in the trophic model of the Lesser Antilles Pelagic Ecosystem (LAPE) by Mohammed *et al.* (2008), although they recognized that the value was very high and probably represented a combination of both mortality and migration.

A crude estimate of the instantaneous fishing mortality (F = 3.3) on an annual basis is also given by Samlalsingh and Pandohee (1992) using Z = M + F. Again, they recognize that this is probably a significant overestimate.

---

[1] These estimates were adjusted slightly by Oxenford *et al.* (2007) to give values (L_4 = 23.2 cm FL, k = 0.01, t_0 = 4 days).
[2] Alternative estimates are available for Tobago-caught flyingfish (L_4 = 25.7 cm FL, k = 0.141 (daily basis), t_0 = -18.6 days) based on unvalidated size-at-age for 20 specimens (Samlalsingh and Pandohee, 1992).
[3] These estimates are loosely corroborated by Samlalsingh and Pandohee (1992), reporting a wide size range for first maturity of between 10.3–17.5 cm FL or 2.9–7.2 months.

Recruitment

H. affinis becomes vulnerable (recruits) to the commercial fishing gear (gillnets and dip nets) at first sexual maturity (from around the age of five months, i.e. about 18.0 cm FL). The population is considered fully vulnerable at age seven months (20.3 cm FL), when the majority of flyingfish are mature (Mahon *et al.,* 2000).

The relationship between recruitment and the adult stock that produces those recruits (i.e. the stock recruitment relationship) for *H. affinis* has been investigated in a preliminary manner (Mahon, 1989). Results indicate that *H. affinis* has a stock recruitment relationship typical of short-lived pelagic species, in which the number of recruits is more strongly influenced by the abiotic and biotic environment (including predation and food supply) than by adult population size, at least over a wide range of adult population sizes. Over the range of spawning stock sizes so far investigated for *H. affinis* in the eastern Caribbean (i.e. those occurring over the years 1958–1984 as indicated by CPUE data from the Speightstown, Barbados, fishing fleet), the average recruitment has been fairly constant, although interannual fluctuations are high. As such, the eastern Caribbean flyingfish stock seems to be characterized by a high degree of interannual variation in abundance (with adult fish biomass fluctuating by a factor of +/- 60 percent from year to year). This variability is believed to be primarily due to the physical environment (rather than adult population size) and is therefore largely unpredictable. Indications are, however, that if flyingfish harvest levels increase by more than 40 percent over the average harvest levels in the 1980s, this may well lead to a decline in recruitment (recruitment overfishing) (Mahon, 1989).

Species interactions

The diet of *H. affinis* comprises largely zooplankton (particularly pteropods/copepods) and nekton (larval fish) (Hall, 1955; Lewis *et al.,* 1962), indicating that they are relatively low down in the food web. They are believed to occupy a trophic level of 3.8K0.56SE (www.fishbase.org; Froese and Pauly, 2009). Predators of juvenile and adult *H. affinis* include many of the large oceanic pelagic species (e.g. dolphinfish, wahoo, large tunas, billfishes) (Oxenford and Hunte, 1999; Heileman *et al.,* 2008). As such, *H. affinis* is an important bait fish for fisheries targeting these large pelagic species.

The strong trophic dependence of dolphinfishes on flyingfishes has been demonstrated using an Ecopath with Ecosim (EwE) model of the Lesser Antilles Pelagic Ecosystem (LAPE) (Mohammed *et al.,* 2008).

Critical habitat

Critical habitat for adult *H. affinis* is clearly open ocean with availability of floating objects to use as spawning substrate. Preferred spawning areas are likely to be present but not well defined at the present time.

A tagging study of *H. affinis* off Tobago has indicated retention of spawning adults in the area (Oxenford, 1994). This information, together with anecdotal information from fishers, suggests that the shelf area off the northwest coast of Tobago may be a preferred spawning area. An abundance survey of *H. affinis* juveniles across the eastern Caribbean indicated a greater density in the area to the northwest of Trinidad and Tobago (Oxenford *et al,* 1995b); however, this could not be corroborated by the relative distribution of *H. affinis* eggs and larvae (Hunte *et al.,* 1995).

MANAGEMENT UNIT

Three genetically discrete subregional stocks of *H. affinis* have been identified so far in the Western Central Atlantic. These are located in the eastern Caribbean, the southern Netherlands Antilles and off northeast Brazil (Gomes *et al.,*1999). As such, the eastern Caribbean *H. affinis* may be considered as a unit stock, shared by the countries of the eastern Caribbean. There is also considerable movement of adult flyingfish between the eastern Caribbean countries, particularly prior to spawning (Oxenford, 1994). This suggests that the minimum appropriate management unit for *H. affinis* should be the combined EEZs of eastern Caribbean countries, from Dominica south to Tobago (Oxenford *et al.,* 1993; Gomes *et al.,* 1999; FAO, 1999).

FISHERY CHARACTERISTICS

The characteristics of the flyingfish fisheries of the eastern Caribbean islands have been described in detailed country reports and regional summary reports on several occasions in recent years. These may be found *inter alia* in the following documents:

- **Oxenford *et al.*** 1993. The eastern Caribbean flyingfish project. *OECS Fishery Report* 9.
- **CFRAMP.** 1996. Small Coastal Pelagics and Flyingfish Sub-project Specification Workshop, Grand Anse, Grenada, 11–13 September. CARICOM Fisheries Resource Assessment and Management Program, SCPFF Assessment SSW/WP/02.
- **FAO.** 1999. Report of and papers presented at the First Meeting of the WECAFC Ad Hoc Working Group on Flyingfish, *FAO Fisheries Report* 613.
- **FAO.** 2002. Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, *FAO Fisheries Report* 670.
- **Oxenford, H.A, Mahon R. and Hunte W.** 2007. Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, University of the West Indies, Barbados, 268 pp.

A brief overview is only given here.

Development

The flyingfish fishery has a long history in several of the islands, and is a more recent development in others. It probably has the longest history in Barbados, where oceanic pelagic species have been a traditional target of the fishery. Records of flyingfish being caught off Barbados go back to the seventeenth century and there are several descriptions of the island's pelagic fishery in the eighteenth and nineteenth centuries (see Storey, 1983; Welch, 2005). Certainly since the mid-1900s flyingfish have been the most important species landed in Barbados in terms of total weight (Prescod, 1996; Parker, 1999, 2002; Willoughby, 2007).

In Dominica, flyingfish have played a historical role as one of the most favoured species by low-income, rural households. This is largely because of the relatively low price charged for flyingfish compared with other pelagic species, and the ease with which they could be preserved by salting, drying or smoking. In recent times, emphasis has been put on processing flyingfish, which has provided fishers with an incentive to increase landings (Norman, 1999; Guiste, 2002; Lawrence, 2007).

In Grenada, flyingfish was traditionally very important as a primary food fish, taken by pelagic boats mainly along the leeward coast and contributing in excess of 40 percent of total fish landings. However, with the development of a small-scale longline fishery in the 1980s, the importance of flyingfish as a food fish declined sharply and they are now caught primarily for bait to support the longline fishery targeting tunas (Finlay and Phillip, 1996; Rennie, 1999, 2002; Phillip and Rennie, 2007).

In Martinique, flyingfish have always been an important component of the "pêche à Miquelon" (offshore seasonal trolling fishery), but landing records have not been taken systematically. In the early 1990s, a processing plant was constructed to debone and package flyingfish, but this has since closed (Doray and Reynal, 2002; Gobert, 2007).

In Saint Lucia, flyingfish have traditionally been harvested by the pelagic fleet and are a reasonably important component of the catch accounting for up to 20 percent of total fish landings (Joseph, 1996; George, 1999; Hubert, 2002; Murray and George, 2007).

In Saint Vincent, flyingfish have never been the target of fishers and the flyingfish resource remains largely unused. The fisheries here have traditionally focused on shallow shelf and slope demersal species (Straker, 1999; Jardine, 2002; Morris, 2007).

The flyingfish resource has been extremely important since the early 1960s in Tobago, and flyingfish may account for up to 75 percent of the island's total catch. Tobago has developed a strong focus on processing and exporting flyingfish, as well as supplying the local market (Mohammed, 1996; Potts *et al.*, 1999, 2002; Samlalsingh *et al.,* 2007).

Early pelagic fishing fleets in the subregion were oar and/or sail powered, but since the introduction of outboard engines in the mid-1900s virtually all of the region's pelagic fishing boats are now mechanized. Most islands' fleets have relatively small open vessels powered by outboard motors. In Barbados, sailboats were replaced by partially covered launches with inboard diesel engines. Since the early 1980s, Barbados has also developed a fairly substantial fleet of larger "ice boats", a few of which are now found in the other island fleets.

The traditional gears used to catch flyingfish was hook and line and the handheld dip net in association with one or more FADs and fish "chum" (macerated fish and oils). Surface floating gillnets were introduced to the Barbados fleet in the 1950s and these are now extensively used throughout the subregion as the primary gear (in association with FADs and chum) to capture flyingfish by any boats specifically targeting this species.

Over the last decade, the general trend in reports of proposed future development of the flyingfish fisheries in the region is to: expand the flyingfish fleet or effort targeted at flyingfish; improve flyingfish landings and effort data collection; upgrade landings, market and storage facilities; improve fish handling; and increase the volume of flyingfish processed, especially for accessing export markets.

Social and cultural importance

The flyingfish fishery is a major contributor to food security, employment and social stability in the coastal communities of many of the eastern Caribbean islands (Ferreira, 2002; Oxenford, 2007). In Barbados, flyingfish has particular cultural significance being: a traditional target of the fishery;

extensively used in tourism promotional material and as a subject in the local art and craft industry; considered as the national dish (flyingfish and *cou-cou*, which is made mainly of cornmeal and okra); and depicted on the Barbados dollar coin. Various indicators of the social importance of flyingfish to the subregion have been summarized in Table 4.

Contribution to the economy

The contribution of fisheries in general to national economies is poorly known, and almost certainly undervalued at a recorded average of less than 2 percent of gross domestic product (GDP) (Ferreira, 2002; Oxenford, 2007) (Table 4). The added value of processed fish, particularly associated with the tourism industry, is often not considered. Likewise, the importance of the employment opportunities offered by the fisheries sector is often overlooked.

The specific contribution of the flyingfish fishery to the GDP is not known for most countries, and employment opportunities are estimates at best. One of the problems with such estimates is that the flyingfish fishery is not species-specific but an integral part of the oceanic pelagic fisheries. This means that jobs on fishing boats, vending or processing or servicing the fisheries sector cannot be attributed solely to flyingfish. However, various indicators of the economic importance of flyingfish to the subregion were assembled by Ferreira (2002) and are summarized in Table 4. At this time, approximately 3 500 fishers were specifically involved in the flyingfish fisheries of the subregion, the majority of these being in Barbados (31 percent), Saint Lucia (26 percent) and Dominica (18 percent). Annual flyingfish landings from this region were estimated at around 3 600 metric tonnes, with an approximate ex-vessel value of US$4.37 million.

A more recent valuation of the fisheries of Barbados in 2006 estimated the ex-vessel value of flyingfish at US$1.79 million and gave a preliminary total value (using added-value of flyingfish products consumed) of US$15.12 million per year in Barbados (Mahon *et al.,* 2007).

Fleets and interactions

Some 1 575 boats ranging from wooden canoes with outboard engines to larger semi-enclosed vessels with inboard engines and ice-holds are active in the flyingfish fisheries of the subregion (Ferreira, 2002, Table 4). Most vessels fish on a daily basis, leaving the beach in the early morning and returning in the mid to late afternoon. These boats fish within 30 nmi of the coastline and may infringe on the EEZs of neighbouring islands. The larger ice boats of the Barbados and Tobago fleets may stay at sea for up to ten days. These boats have much larger fishing ranges (> 100 nmi) and fish in some cases beyond the EEZs of their country of registration.

There are significant trophic, technical and economic interactions between the flyingfish fisheries and the fisheries targeting large oceanic pelagic species (e.g. dolphinfish, wahoo, tunas, billfishes) (Mohammed *et al.,* 2008; Fanning and Oxenford, 2009). Flyingfish is not only an important prey species for many of the large pelagic species (Oxenford and Hunte; 1999; Heileman *et al.*, 2008), but also very few vessels take exclusively flyingfish or large pelagic species on any given fishing trip and flyingfish is an extremely important bait fish for the large pelagic species. Given these facts, there is strong justification for an ecosystem-based approach to the management of the eastern Caribbean pelagic fisheries (Grant, 2008; Fanning and Oxenford, 2009).

TABLE 4

Social and economic indicators of the importance of flyingfish to the eastern Caribbean. Adapted from Ferreira (2002). New data from: Medley *et al.*, 2009[1]; C. Parker, Barbados Fisheries Division (personal communication)[2]

Indicators	Barbados[2]	Dominica	Grenada	Martinique	Saint Lucia	Saint Vincent and the Grenadines	Tobago
Contribution of flyingfish fishery to national employment	1 100 fishers. 450 persons in flyingfish post-harvest sector. 550 non-fisher vessel owners. 7 fish processing plants.	615 fishers (31% of total fishers). 54 non-fisher boat owners Many wives of fishers in post-harvest sector. 1 fish processing plant.	423 fishers (estimate). Many non-fisher boat owners	A few hundred fishers	915 fishers	2 500 fishers (none target flyingfish). 500 vendors, processors, etc.	228 fishers 200 persons in processing 4 major and 3 minor processing plants. Many cottage processing industries.
Number of boats in the flyingfish fishery	408	544	163	NA	305	300 (none target flyingfish)	127
Composition of flyingfish fishery fleets	240 day boats 168 ice boats	197 canoes 308 keel boats 39 fibreglass boats	60 ice boats 55 cabin pirogues 48 open pirogues	NA	163 canoes 122 pirogues 20 shaloops	-	126 pirogues/bumboats 1 ice boat
% of total fishing fleet landing flyingfish	43	57	NA	NA	32	60	18
Investment in flyingfish harvest sector (US$)	NA	2.44 million	5.63 million	NA	5.65 million	NA	NA
Total estimated flyingfish catch (metric tonnes)[1]	1 288 (2007)	36.1 (2007)	385.1 (most of this for bait)	370 (2007)	46 (2007)	1 (2007)	210 (2008)
Flyingfish as % of total fish landings	62 (avg. 1998–2007)	3	< 1	11.3 (1987)	4	< 1	75
Price of flyingfish (US$ kg)	0.83–1.61 (wholesale)	0.81–1.85	0.81 (wholesale) 1.63 (retail) 1.85 (processed)	1.50–7.00 (wholesale)	1.63–2.03 (retail)	-	0.69 (wholesale)
Value of flyingfish production (US$)	2 000 000 (wholesale) 20 000 000 (value added) (avg. 1998–2007)	87 076	270 000	1 000 000– 3 000 000 (1987)	136 054	-	61 986 (ex-vessel) 123 971 (retail) (1990/91)
Contribution of fisheries to national economy (% GDP)	0.4 (2005)	1.8 (1999)	1.4 (1999)	NA	1.16 (1999)	2	0.2 (1998)
Export flyingfish	Y	N	Y	N	N	N	NA
Value of flyingfish exports (US$)	52 500 (avg. 2000–2006)	-	2 407 (estimate)	_	-	-	
Import flyingfish	Y	N	Y	NA	Y	Y	Y
Value of flyingfish imports (US$)	34 500 (1999)	-	NA	-	101 501 (1999)	4 037	215 600 (1999)
Fishers' organizations	5 active under umbrella of Barbados National Union of Fisherfolk Organizations	8 cooperatives	3 associations and 2 cooperatives under National Fishermen's Association	1 association	9 cooperatives	NA	8 associations 2 cooperatives 1 federation

Catch and effort

Best estimates of total annual catches of flyingfish from the eastern Caribbean stock over the period 1950–2007 have been reconstructed from landings records and data interpolation (Medley *et al.,* 2009) and are shown in Figure 5. Total annual catch estimates for flyingfish from this subregion were highest in the late 1980s through 2003 with catches approaching 5 000 tonnes, but have declined in recent years to around 2 000 to 2 500 tonnes (Figure 5). Barbados has always contributed the majority of the subregion's flyingfish catches and has been responsible for around 50 percent in the last decade (Figure 5).

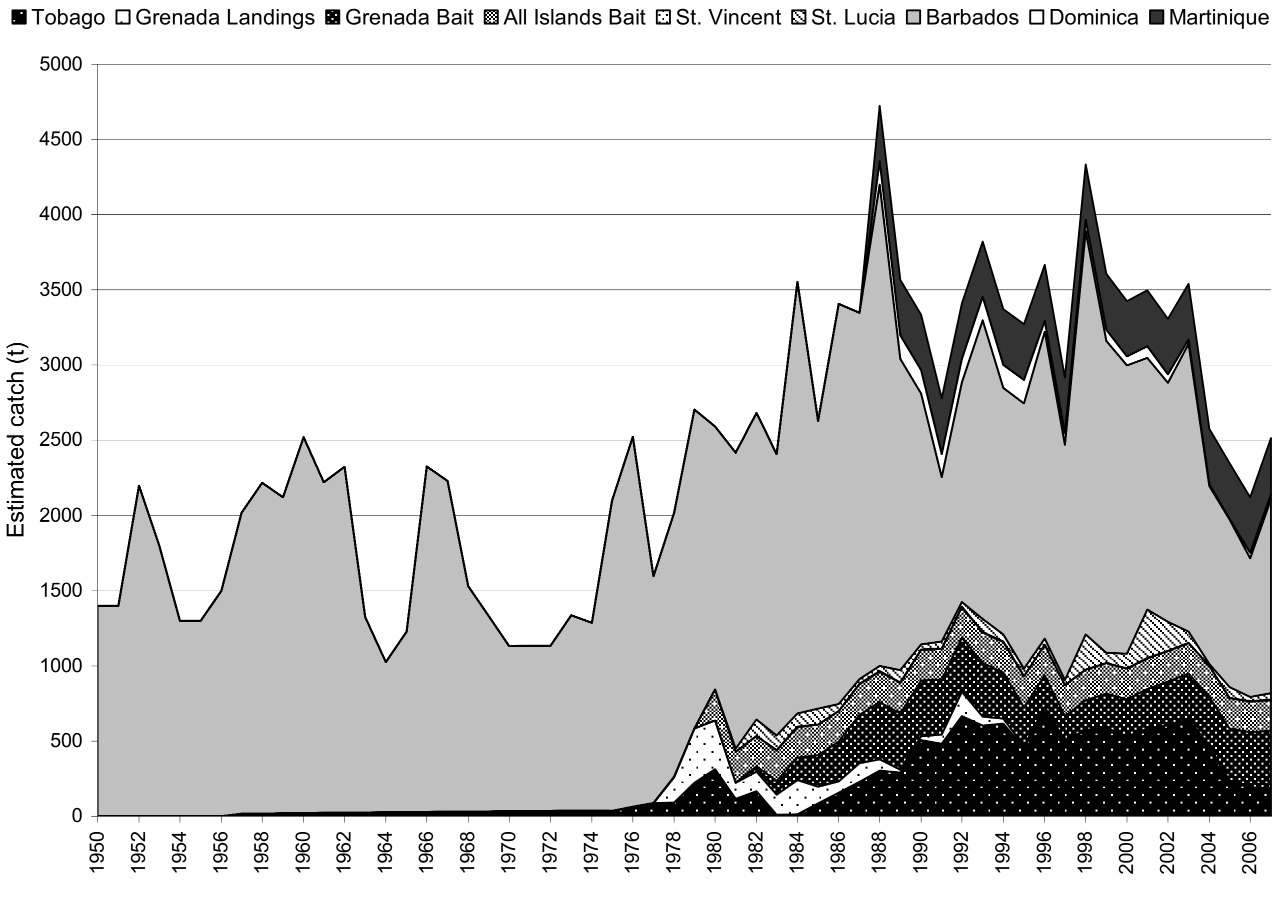
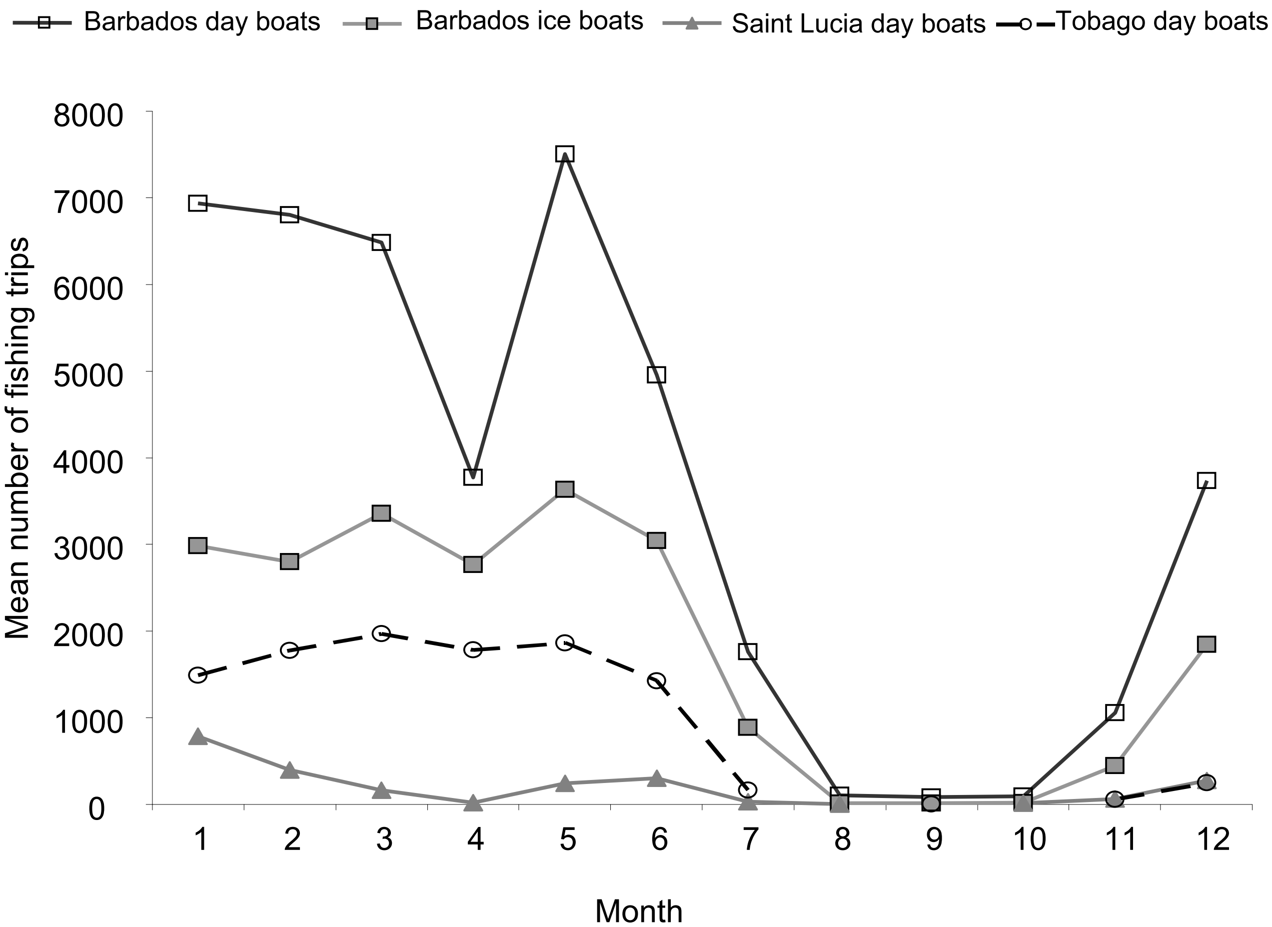


Figure 5. Stacked chart, showing the estimated total annual catches of flyingfish for the eastern Caribbean (1950-2007). After Medley *et al.,* (2009).

The most recent estimates of fishing capacity indicated that around 1 575 boats and 3 500 fishers were directly involved in harvesting flyingfish in this subregion (Ferreira, 2002). Although fishing effort (trip) records are now collected by several of the islands (using TIP [Trip Interview Program] or CARIFIS [Caribbean Fisheries Information System] software), it should be noted that they do not necessarily reflect the fishing effort specifically targeted at flyingfish. Obtaining this information is complicated by the fact that fishing trips are usually multispecies and considerable time may be spent fishing for large pelagic species on any given trip.

The fishing effort for flyingfish is highly seasonal (December to June), driven by the seasonal availability of both flyingfish and the large pelagic species, particularly dolphinfish. The most recent estimates of fishing effort in the subregion, in terms of the number of fishing trips during which flyingfish were caught, were assembled by Medley *et al.* (2009) for Barbados, Tobago and Saint Lucia for the period 1988–2008. The monthly mean fishing effort over this period is shown in Figure 6 and demonstrates the very low fishing effort during the summer (July to November). The mean total number of flyingfish fishing trips conducted per year by the fleets of these three countries over this period is in excess of 78 200. Barbados day boats account for the majority of fishing trips averaging 43 300 per year, followed by Barbados ice boats averaging around 21 800. Tobago day boats



contribute on average 10 800, while Saint Lucia day boats make some 2 300 trips per year.

Figure 6. Seasonality of fishing effort shown as monthly mean number of recorded fishing trips (1988–2008) by the flyingfish fishing fleets of Barbados, Tobago and Saint Lucia. After Medley *et al.*, (1990).

A further complication, when examining the regional fishing effort database, is the difference in fishing power among the different boat types and national fleets. This is particularly problematic when using catch per effort (catch per fishing trip) as an index to examine trends in flyingfish abundance over time. Medley *et al.* (2009) attempted to standardize the catch per unit effort data of Barbados, Tobago and Saint Lucia for the last two decades (1988–2008) against the January catches of the day-boat fleet in Barbados each year. The resulting catch per unit effort time series is shown in (Figure 7) and suggests that flyingfish abundance has remained stable over the long term.

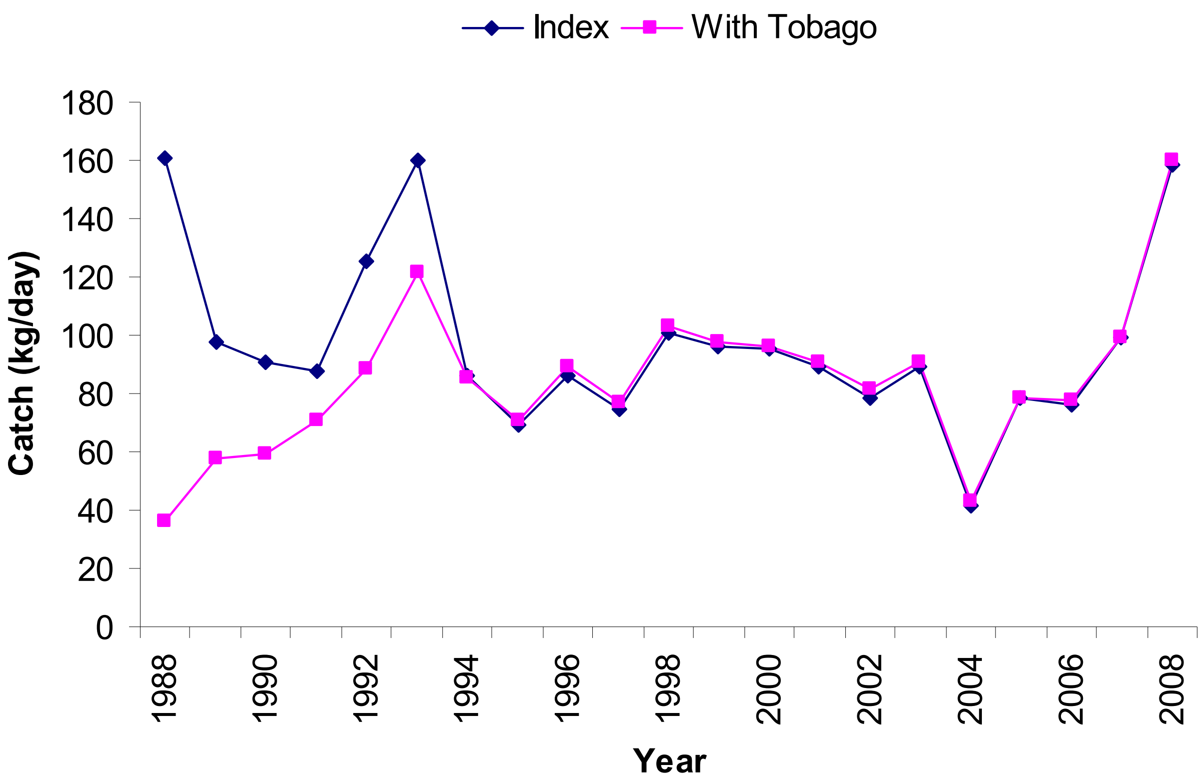


Figure 7. Standardized index of abundance for eastern Caribbean flyingfish representing catch per unit effort data for Barbados, Saint Lucia and Tobago, standardized annually to Barbados January day-boat effort (trips). After FAO (2009) Part I, and Medley *et al.,* (2009).

Gear and methods

Although there are clear differences in boat types and subtle differences in fishing technique among different national fleets, all fishers use the same basic gear and methods to catch flyingfish (see Oxenford *et al.,* 2007). Flyingfish are generally caught offshore (> 5 nmi) from a drifting boat to which they are attracted by the use of FADs (generally made from bundles of banana or coconut leaves or from sugar cane trash) and fish chum. These FADs are attractive to mature flyingfish as spawning substrate. The fish are primarily taken by surface gillnets, or when gathered closely around the boat in a spawning school they are preferentially taken by the traditional handheld dip net. When flyingfish are being taken in smaller quantities as bait, they are generally taken by hook and line, baited with a small piece of fish flesh. The gillnets and dip nets used to catch flyingfish are highly species-specific, but fishers tend to target other large pelagic species with different gear (e.g. trolling lines and lurking lines) during the same fishing trip, so the catch from a pelagic fishing trip is likely to be multispecies.

Policy and legislation

Fisheries policy and legislation varies among the eastern Caribbean islands. Most islands, under the guidance of the CFRAMP programme, have written fishery management plans, some of which contain plans specifically for flyingfish (e.g. Barbados, Dominica, Saint Lucia). All of the islands agree that management of the eastern Caribbean flyingfish resource must be a collaborative venture among all participants in the fishery. Policy statements from most Fishery Divisions in relation to the flyingfish fishery focus on sustaining catches and improving infrastructure.

Most islands require some form of registration and licensing as a fisher, but so far for the pelagic fleet this is free of charge and unrestricted. Few islands have fishery regulations that pertain specifically to flyingfish. In Barbados, the only regulation potentially impacting on the flyingfish fishery is a restriction on the maximum length of gillnets to less than 2.5 km. This regulation currently has no impact on local boats since the gillnets used are considerably smaller than this.

Safety

Safety at sea is an important issue for sustainable development of the fishery. The use of mechanized vessels has certainly decreased the incidences of capsizing and loss of life at sea which occurred when sailboats were prevalent. However, engine failure and overloading of small boats remain problematic areas for concern. The amount of safety and navigational equipment carried by the subregion’s flyingfish fleets is highly variable and is often constrained by boat size (e.g. in the case of canoes, open pirogues, bumboats). These vessels may have negligible safety equipment. In the case of the larger boats (e.g. ice boats) which have an enclosed cabin and accommodation, a full complement of safety and navigational gear is often carried. This includes very high frequency radio, single sideband radio, radar reflectors, compass, Global Positioning System, flares, first aid kit, lifejackets, fresh water, dried and tinned foods.

Insurance and credit facilities

Access to reasonably priced insurance and credit facilities has a history of being problematic in the fishing industry. A summary of the situation in 2001 regarding access to credit in the form of loans and monetary fishing incentives is given in Table 5.

Post-harvest sector

The development of the post-harvest sector for flyingfish is quite variable among the eastern Caribbean islands. In all of the islands, there is direct marketing of whole flyingfish to vendors and/or the public. Vendors may sell whole flyingfish to the public or may debone the fish and sell fresh fillets. Vendors may operate from a designated fish market, from roadside stalls, or may drive the fish into the hinterland selling directly from the vehicle.

In Barbados and Tobago, there is a strong emphasis on processing flyingfish. A high proportion of the catch is purchased wholesale by commercial and small-scale processors. Most is filleted, vacuum packed and frozen. In Barbados, the majority of the processed flyingfish is sold locally to supermarkets and restaurants. In Tobago, the majority is exported. Saint Lucia, Dominica and Grenada also process flyingfish in a similar way but on a smaller scale.

TABLE 5
Summary of availability of credit and monetary fishing incentives. Adapted from Ferreira (2002)

Country	Credit	Fishing incentives
Barbados	• Commercial banks unwilling to provide loans to fish harvest sector • Barbados Development Bank was mandated to provide loans to the fisheries sector but closed in 1995	• Duty-free concessions on boat, engines, gear, etc.
Dominica	• Access to loans from credit unions, Agricultural, Industrial and Development Bank, and National Development Foundation of Dominica • Government credit facility provides loans to fishers without security • Rate of interest 12.5% (1.5% higher than loans for housing, vehicle)	
Grenada	• Grenada Development Bank provides loans at interest rate of 10.5–12%, collateral required • Commercial banks provide loans at interest rate of 12.5%. Rate increases if no collateral • Government low interest rate, soft loan scheme following Hurricane Ivan in 2004	• Duty-free concessions on boat, engines, gear, etc. • Fuel rebates • Government compensation and/or assistance in event of emergencies/natural disasters
Martinique	NA	NA
Saint Lucia	• Soft loan facility offered through Saint Lucia Development Bank • Some credit unions provide loans for fishing vessels • Some aid programmes, e.g. Saint Lucia Rural Enterprises Project (SLREP) offer financial assistance • Interest rate of 11% per annum. Repayment period of 5 years	• Subsidies on fuel, boats, engines, gear available to cooperative members
Saint Vincent and the Grenadines	NA	NA
Trinidad and Tobago	• Loans provided by credit unions and Agricultural Development Bank (ADB), commercial banks • Loan of up to 70% of value of boat, etc., at interest rate of 15-17% per annum at ADB, and 15–19% at commercial banks, with repayment period of 5–7 years for boats, and 1–3 years for engines	• Subsidies on fishing vessels and vehicles for transporting catch • Value added tax waivers on engines and marine accessories • Fuel rebates

STATUS OF THE FISHERIES

State of the stock

The state of the stock is based on the most recent stock assessment (FAO, 2009; Medley *et al,* 2009). According to this assessment, the eastern Caribbean flyingfish stock is not overfished and overfishing is not occurring.

The catch rates have remained stable overall in the 20-year time series (1988–2007 inclusive) as catches have increased (Figure 7). Given the potential stock area, and estimates of a relatively large stock size from tagging and survey estimates, it is likely that the potential yield exceeds total catches taken during the history of the fishery.

Although there is no evidence of a decline in flyingfish abundance from the current time series of flyingfish catch and effort data, it should be noted that such a depletion would not be expected to become evident until the stock went into a significant decline given the life-history characteristics (short life span, high fecundity) of *H. affinis*.

Issues and constraints

A number of problems currently exist which are constraining the development and management of the flyingfish fishery in the eastern Caribbean. Some of the key issues and constraints for all or some of the countries, which require consideration for action strategies in the subregional management plan, are listed here:

- lack of a regional mechanism for managing shared resources;
- inadequate fishery information and statistics (particularly socio-economic data) for planning and management;
- inadequate human capacity in fishery departments to conduct required level of research and data analysis;
- inadequate development of participatory management with all stakeholders at national and subregional levels;
- constrained access of far-ranging vessels (e.g. Barbadian ice-boat fleet) and other near-ranging fleets (e.g. French boats) to fishing areas occupied by the shared *H. affinis* stock;
- market gluts occurring as a result of bunched landings and inadequate distribution leads to lowered incentive to harvest flyingfish when plentiful;
- marked seasonality in availability of *H. affinis* leads to discontinuous market supply and seasonal fishing effort;
- limited facilities for disposal or use of fish offal at landing sites;
- limited landing site and marketing facilities in some countries;
- inadequate post-harvest technology to ensure a good quality product and reduce fish wastage;
- aging population of fishers with insufficient new entrants;
- lack of, or inadequate, safety equipment and navigational training of crew for some boat types;
- difficulties with accessing credit in the fisheries sector;
- some eastern Caribbean countries have significant difficulties with producing cost-competitive local exports of fresh flyingfish or fish products as a result of very different national economies;
- poor quality of landed fish from improper bulk storage at sea and ashore;
- labour shortage and lack of adequate blast freezing facilities for processing plants;
- lack of monitoring, surveillance and enforcement; and
- competition for use of the coastal zone.

Opportunities

A number of expansion and development opportunities exist within the flyingfish fisheries of the subregion, while bearing in mind the current precautionary management objective. Current opportunities include:

- development of local value-added flyingfish products of competitive quality;
- accessing specialized niche markets in North America and the United Kingdom of Great Britain and Northern Ireland;
- expanding frozen fish storage facilities to reduce seasonality of fish availability;

- expanding range of current fishing fleets into geographic range of the eastern Caribbean *H. affinis* unit stock;
- development of gear to target underutilized flyingfish species available in the region (e.g. *Parexocoetus brachypterus*);
- development of products utilizing fish offal;
- development of flyingfish deboning skills in all eastern Caribbean islands to increase value of fresh fish; and
- development of better fish distribution mechanisms for marketing fresh fish in rural areas.

MANAGEMENT OBJECTIVES AND INDICATORS

The management objective is to ensure responsible and sustained fisheries, such that the *H. affinis* resource in the waters of the eastern Caribbean is optimally utilized for the long-term benefit of all people in the eastern Caribbean region.

Responsible management in the face of uncertain information on the true status of the flyingfish stock requires a precautionary approach.

The significant trophic, technical and economic linkages between the flyingfish fisheries and the fisheries targeting large oceanic pelagic species (e.g. dolphinfish, wahoo, tunas, billfishes) provide strong justification for an ecosystem-based approach to the management of these fisheries.

The flyingfish stock is shared among the eastern Caribbean islands and as such these islands are legally obligated to collaborate in its management. An institutional arrangement allowing for subregional collaborative management is therefore critical.

Reference points

Management should be guided by reference points and indicators. Typically, specific target reference points (TRPs) and limit reference points (LRPs) are used to guide management towards desirable harvest levels to ensure a sustainable fishery over the long term (Caddy and Mahon, 1995; Caddy, 2002). These reference points may be strictly based on biological models that are concerned with sustainable yields from the resource, or economic models that are concerned with sustainable profits, or they may be guided by social considerations.

Biological models: Relatively precise reference points are typically drawn from yield prediction models (e.g. yield per recruit[4] and surplus production models). Less precise guidance may simply be drawn from knowledge of life-history characteristics (e.g. size of fish at maturity[5]).

Surplus production (F_{msy}, 2/3 F_{msy}, B_{MSY}): Current fisheries management practice is to consider maximum sustainable yield (MSY) as a harvest LRP. A TRP should always be set well below the LRP. There is little to guide how much the TRP should be set below the LRP for *H. affinis*. In international fisheries management, the conventional precautionary approach has been to set a target

---

[4] *Yield per recruit (F_{max}, $F_{0.1}$):* Yield-per-recruit analysis (which is often used to determine the fishing mortality required to maximize yield, based on growth and mortality patterns with age) indicates for flyingfish that yield is maximized at a level of fishing (F_{max}) that would endanger the reproductive capacity of the *H. affinis* stock. Even a precautionary level of fishing ($F_{0.1}$) would reduce the mature spawning stock biomass to unacceptably low levels (Oxenford *et al.,* 2007b). Therefore, yield-per-recruit models should not be used to set a TRP for this species.

[5] *Size of fish:* A rational TRP based on fish size would ensure that the average size landed by the fishery is greater than the average size at first maturity, which for *H. affinis* is around 18.0 cm FL. Since the current fishery targets spawning fish, it is unlikely that many will be taken before reaching maturity. As such, this would not be an appropriate TRP for this fishery.

at 2/3 estimated MSY. Once a reliable MSY estimate is available, this reference point should be established, giving guidance on total allowable catches and fleet capacity.

The flyingfish stock should not be reduced below B_{MSY}. Current evidence suggests that the stock is well above this limit, but where the limit lies is highly uncertain. As such, a formal reference point based on MSY is too uncertain at this time for the flyingfish stock. However, a trigger point can be established based on total catch and using the most recent stock assessment (Medley *et al.,* 2009) to ensure that fishery development is monitored carefully and ultimately limited to ensure sustainability of the resource.

An interim catch limit (trigger point) for the subregional stock, based on the recent stock assessment, should be set at:

- **Trigger point: 5 000 tonnes annual catch**

Sustained catches at or above this level are expected to bring about an unacceptable risk of overfishing. Either catches must be maintained below this level, or further research, data collection and stock assessment work is required to enable a new higher limit to be set while still ensuring that the limit is safe.

The long-term aim would be to take a fixed proportion of the stock each year based on the MSY. As yet, the estimate of this proportion is too imprecise to suggest any particular value, but it is very likely that the catch taken each year would exceed current catches. As this target catch is approached, further controls would be required to ensure the biomass was not depleted below the MSY point. If the intention is to develop this fishery, much improved data collection would be required to avoid the risk of overfishing.

Data and monitoring requirements

If the subregional harvest is to be controlled at or below the trigger point (5 000 tonnes per year), accurate total harvest data for all countries sharing the flyingfish stock must be collected and shared in a timely manner.

Reducing the uncertainty in the current stock assessment will require improved catch and effort data from the entire subregion, including catch used directly as bait.

CONTROLS

At the current time there is no requirement for controlling the fishing effort or harvest of flyingfish in the subregion since current catches are believed to be well below the agreed catch trigger point of 5 000 tonnes.

However, various tools typically used in fisheries management for constraining catch levels are examined here with regard to their potential use in the future.

Output controls

Tools which are used to control the fishery output (harvest) include direct measures such as a total allowable catch (TAC) or individual quotas (IQs) and less precise measures such as bag limits and size limits.

TACs/IQs

A key issue with constraining total catch from the subregional flyingfish stock is the allocation of the annual TAC among participating countries. This may be based on historical catch levels, on relative size of EEZs, or some other combination of criteria.

A TAC approach can be implemented in various ways. The simplest approach is an open TAC for the *H. affinis* stock each fishing season. However, in this situation, competition between fishing units for the TAC would probably result in the development of excess fishing capacity (overcapitalization). This might decrease the proportion of spawning occurring early in the season, with the longer-term risk of decreasing the availability of fish early in the season, and hence reducing the duration of the fishing season. Another approach is to implement a TAC either by setting quotas for periods within the spawning season (e.g. monthly TACs) which would reduce competition between fishing units, or by allocating IQs to each fishing unit or enterprise which would prevent competition between them. A monthly TAC approach would ensure a more even distribution of catch over the fishing season than an open TAC. With an IQ approach, units would harvest their quotas on a schedule which would optimize their economic returns. This would probably result in a relatively even distribution of effort over the fishing season.

Despite the potential benefit of a TAC approach in protecting spawning stock biomass, it has considerable ongoing research and monitoring implications. Fishery managers must have the capability to monitor current cumulative catch and to close the fishery, or fishing operations of a unit, when the TAC or IQ has been reached. This requires a considerable commitment of management resources, and will be particularly difficult under a regional management regime. A further complication is the multispecies nature of the flyingfish fishery and the fact that it has significant technical and economic linkages with the fisheries for large pelagic species, including the longline fishery that would likely be severely impacted by a closure of the flyingfish fishery.

A potential advantage of the TAC approach is that the TAC can be changed from year to year in response to the abundance of fish. However, to realize this advantage, the fishery manager must be able to predict the abundance in the coming season, and there must be the fishing capacity to take advantage of extra TAC in years of high abundance. The information required to accurately predict flyingfish abundance in the coming season is not yet available and will be difficult to obtain.

Bag limits

The use of a bag limit, whereby an individual or a boat is restricted to a certain limit of fish per fishing trip, would not be a practical tool in the case of the flyingfish fisheries. The monitoring requirements would be huge (check every boat after every trip). Furthermore, since flyingfish are caught in spawning schools which are unevenly distributed, the catch rate for any given boat can be enormously variable from day to day depending on whether or not a school was encountered. Catches may often be zero, and occasionally may be very high.

Size limits

The use of a minimum size for landed flyingfish would be inappropriate given the enormous task of monitoring this. Furthermore, the gear type most commonly used at present is the gillnet from which fish cannot survive if released. Since flyingfish grow very little after reaching maturity, and the fishery relies on targeting spawning fish, it would be very difficult to impose a meaningful size limit.

Input controls

Tools which are used to control the fishery input (fishing effort) include direct measures such as limited entry/licensing, and less precise or complementary measures such as closures, gear limits and monetary incentives or disincentives.

Limited licensing

A key issue with constraining total fishing effort through limited licensing will be the allocation of allowable effort (licences) among eastern Caribbean stakeholders in the fishery. Furthermore, since boat types fishing flyingfish vary significantly among stakeholders, the total allowable fishing effort will need to be expressed in terms of number of "standard" fishing units, such as those with the lowest fishing power (e.g. canoes). This will require intercalibration of the various boat types to allow the conversion of the effort allocation to actual number of a particular boat type. A limited effort approach is also somewhat crude compared with using a TAC since a licensed boat could improve its fishing efficiency over time but is probably the most appropriate tool at this time.

Closures (seasonal, moratorium, marine protected areas)

Since the fishery must take place during the spawning season, the spawning stock could be protected by closing the fishery during a part of the season. A major consideration would then be the timing of the closure. Spawning of flyingfish extends over six to eight months, from November through June, and individual fish may spawn several times. There appear to be two peaks of spawning activity: a minor one around November–December, and a major one in April–May. The bimodality in spawning activity may indicate that there are two distinct groups of flyingfish each with its own spawning period. Alternatively, and more likely, since the mean size of flyingfish increases steadily from November to April, it may be due to environmental influences on a single extended spawning period.

If there are two distinct spawning groups, both must be protected; otherwise, one or the other may collapse. Therefore, a closed period approach would have to ensure that there was at least one closed period for each spawning group. In either case, in an intensive fishery, taking the majority of the catch from one part of the season would shift the timing at which most spawning occurred. Instead of being distributed over the entire season, it would become concentrated in the closed period. This could have a number of undesirable effects which cannot be easily predicted at this time because they will depend on a number of characteristics which are presently unknown. These are primarily the frequency and duration of spawning of individual fish relative to the entire spawning season, but also include the extent to which the environmental characteristics which are favourable for survival of young flyingfish vary over the spawning season.

It would probably be inappropriate to implement management which would affect the timing of the spawning season until the likely effects can be better evaluated. However, if a closed season is considered to be the most logistically feasible method of protecting the spawning potential of flyingfish, one approach could be to have several closed seasons over the spawning period. Another would be to shift the closed season within the spawning season from year to year.

Socio-economic implications of a closed season approach will include the effects of closure on the economics of fishing operations and on the supply of fish to processors and consumers and would be complicated by the linkages to other fisheries. These effects will be aggravated if more than one closed period is used per fishing season.

Present data suggest that flyingfish spawn throughout the eastern Caribbean, but may spawn more prolifically in some areas than in others. However, further information is required to accurately identify preferred spawning locations if in fact they do exist before considering the use of closed areas as a management tool.

Gear limits

It should be noted that there is little or no potential to influence the size of *H. affinis* caught, or to affect the timing of capture of the fish by regulating the mesh size of the gillnets or dip nets. *H. affinis* grow very little after they mature. Therefore, they vary little in size throughout the spawning season. Any change in gillnet mesh size has been observed to result in markedly lower catch rates, rather than a shift in the mean size of fish caught (Mahon *et al.,* 2000). A change in the mesh size of dip nets would make no difference to the size of fish scooped up.

The practice of using tethered FADs to attract spawning adults may have management implications for recruitment. These FADs often become covered with eggs, and are brought back to shore by fishers. If, as research results suggest, floating spawning substrate is scarce, the eggs removed from the stock in this way may be a significant component of reproductive output. It may therefore be advantageous to require that fishers set their FADs adrift at the end of each fishing trip.

Monetary

The use of monetary incentives or disincentives is a particularly crude way to control harvest rates for flyingfish and are unlikely to be acceptable.

IMPLEMENTATION PLAN

Institutional and legal arrangements

Implementation of a subregional management plan for a shared *H. affinis* stock requires appropriate institutional and legal arrangements among the eastern Caribbean countries participating, or interested in participating, in the flyingfish fisheries. An impartial subregional body is likely to be required. This could be the Caribbean Regional Fisheries Mechanism with guidance from the WECAFC Ad Hoc Flyingfish Working Group.

Co-management

The nature of the *H. affinis* stock (shared, migratory, open ocean) constrains the opportunities for effective co-management of this resource in the strictest sense. However, participatory management, whereby stakeholders are actively involved in the decision-making and management process, should be encouraged. Functional fisheries advisory committees in each of the countries would help to serve this role.

Time frame

Given the fact that pelagic fishing fleets of the eastern Caribbean are likely to continue expanding, and the fact that an ecosystem-based approach should be adopted, there is some urgency for early adoption of the management plan and an improved catch and effort data monitoring system across all countries participating in the pelagic fisheries.

Monitoring, control and surveillance

Monitoring of the flyingfish fishing fleets will be required for the current fisheries management plan to be effective. Monitoring could be done at the national level by the fisheries divisions. Control and surveillance will need to be done once the trigger point is reached, and this should be at the subregional level, coordinated by an impartial body. The exact mechanism by which this will be implemented needs to be considered further by the subregional management body.

Data collection, sharing and analysis

In order to affect subregional management of sustainable flyingfish fisheries, data collection from the shared flyingfish stock should be standardized, pooled and analysed on an ongoing basis. The subregional management body could be responsible for data analysis in association with the Ad Hoc Flyingfish Working Group.

Financing

Financing implementation of a subregional management plan should largely be done at the national level (monitoring, control and surveillance), but will need additional funding for collation and analysis of the regional database. This should be handled by the subregional management body in association with the Ad Hoc Flyingfish Working Group, the latter currently being funded by WECAFC.

Research

Research requirements for developing and improving a comprehensive subregional management plan for flyingfish are listed in Table 6.

TABLE 6
Research needs for further development of the regional management plan for flyingfish in the eastern Caribbean. Adapted from Oxenford *et al.* (1993)

Research area	Priority	Time frame
Obtain accurate total catch and CPUE data throughout the region, including estimation of: (i) amount of flyingfish caught for bait; (ii) total time/effort spent specifically targeting flyingfish; and (iii) effects of gear competition on current catch rates.	High	Long-term
Improve estimate of flyingfish abundance through: (i) investigation of flyingfish depth distribution and proportion of school flying at approach of a survey vessel; (ii) additional tagging studies; (iii) checking the correlation between adult abundance as indicated by survey data and catch rates obtained in the same area at the same time; and (iv) investigating whether or nor significant local depletion occurs when boats fish in a particular area (possible management implications for access of far-ranging fleets fishing a common stock).	High	Long-term
Further studies on spawning behaviour of flyingfish aimed at investigating: (i) whether or not benthic spawning occurs; (ii) whether spawning on surface substrates continues until these sink; (iii) the frequency and duration of individual fish spawning relative to the spawning season; (iv) whether or not there are distinct preferred spawning areas/grounds (requiring special management attention); and (v) whether or not two spawning periods represent two substocks (implications for closed season or seasonal TAC management).	High	Long-term
Refine risk assessment model to facilitate investigation of: (i) effects of oceanographic and biotic variables on stock recruitment relationship to improve yield predictions; and (ii) impact of closed season and closed area management options on stock rebuilding.	High	Long-term
Estimate mortality factors on flyingfish (e.g. predation mortality on spawners)	Medium	Long-term
Standardize effort data throughout the region by calculating fishing power conversion factors for different fishing vessel types in the flyingfish fishery.	Medium	Long-term
Conduct comprehensive socio-economic study of the flyingfish fishery.	Medium	Long-term
Investigate FAD use to: (i) assess the impacts on fishers of compulsory release of FADs when laden with flyingfish eggs (removal of FADs may constrain population size?); and (ii) consider alternative FAD designs that facilitate the safe removal of eggs without necessitating loss of the whole FAD.	Low	Short-term
Explore feasibility of commercial exploitation of *Parexocoetus brachypterus*.	Low	Long-term

REFERENCES

Alagaraja, K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian Journal of Fisheries,* 31: 177-208

Barbados Fisheries Division. 2001. Barbados Fisheries Management Plan 2001–2003. Schemes for the management of fisheries in the waters of Barbados. Fisheries Division, Ministry of Agriculture and Rural Development, Government of Barbados, 72pp.

Barbados Fisheries Division. 2004. Barbados Fisheries Management Plan 2004–2006. Schemes for the management of fisheries in the waters of Barbados. Fisheries Division, Ministry of Agriculture and Rural Development, Government of Barbados, 67pp.

Caddy, J.F. 2002. Limit reference points, traffic lights, and holistic approaches to fisheries management with minimal stock assessment input. *Fisheries Research,* 56: 133-137.

Caddy, J.F. & Mahon, R. 1995. Reference points for fisheries management. *FAO Fisheries Technical Paper,* 347, 83pp.

Campana, S.E., Oxenford, H.A. & Smith, J.N. 1993. Radiochemical determination of longevity in flyingfish (*Hirundichthys affinis*) using Th-228/Ra-228. *Marine Ecology Progress Series,* 100: 211-219

CFRAMP. 1996. Small Coastal Pelagics and Flyingfish Sub-project Specification Workshop, Grand Anse, Grenada, 11–13 September. CARICOM Fisheries Resource Assessment and Management Program, SCPFF Assessment SSW/WP/02.

Doray, M. & Reynal, L. 2002. National flyingfish report from Martinique. Pp. 116-119, *in:* FAO (ed.). Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report*. No. 670.

Fanning, L.P & Oxenford, H.A. 2009. Ecosystem issues pertaining to the flyingfish (*Hirundichthys affinis*) fisheries of the eastern Caribbean. Pp. in press, *in*: Fanning, L., R. Mahon and P. McConney (eds.) Marine ecosystem based management in the Caribbean. Island Press, Washington DC. Accepted 4 June 2009.

FAO. 1999. 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. 45pp.

FAO. 2002. Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. *FAO Fisheries Report.* No. 670. 155 pp.

FAO. 2008. FAO yearbook of fishery and aquaculture statistics 2006. Rome, FAO. 57 pp.

FAO. 2010. Report of the Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean. Mount Irvine, Tobago, 21–25 July 2008. *FAO Fisheries and Aquaculture Report.* No. 929. 88 pp.

Ferreira, L. 2002. Social and economic assessment of the eastern Caribbean flyingfish fisheries: A regional perspective. Pp. 146–156, in: FAO (ed). Report of the second meeting of the WECAFC ad hoc flyingfish working group of the eastern Caribbean, Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report*. No. 670.

Finlay, J. & Phillip, P. 1996. Small coastal pelagic fisheries in Grenada: National report. Presented at: CFRAMP Small Coastal Pelagics and Flyingfish Workshop. 11–13 September, Grenada SSW/WP/06, 11 pp.

Froese, R. & Pauly, D. (eds). 2009. FishBase. World Wide Web electronic publication. www.fishbase.org, version (09/2009).

George, S. 1999. National report of Saint Lucia: characteristics and status of the flyingfish fishery. Pp. 22-26, *in:* FAO (ed.). Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report*. No. 670.

Gobert, B. 2007. The flyingfish fishery of Martinique. Pp. 17-21, *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Gomes, C., Oxenford, H.A. & Dales, R.B.G. 1999. Mitochondrial DNA D-loop variation and implications for stock structure of the fourwing flyingfish, *Hirundichthys affinis,* in the central western Atlantic. *Bulletin of Marine Science,* 64: 485-500.

Grant, S. 2008. Assessment of fisheries management issues in the Lesser Antilles and the ecosystem approach to fisheries management. Technical Document No. 9 of Scientific Basis for Ecosystem-Based Management in the Lesser Antilles including Interactions with Marine Mammals and Other Top Predators. FAO, Barbados, FI:GCP/RLA/140/JPN, 254pp.

Guiste, H. 2002. Social and economic study of the flyingfish fishery sector of Dominica. Pp. 94-102, *in:* FAO (ed.). Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report*. No. 670.

Hall, D.N.F. 1955. Recent developments in the Barbadian flying-fish fishery and contributions to the biology of the flying-fish, *Hirundichthys affinis* (Günther). Colonial Office, Fishery Publications 7:1-41

Heileman, S., Mohammed, E. & Fanning, P. 2008. Derivation of diet compositions in the Lesser Antilles pelagic ecosystem. Scientific basis for ecosystem-based management in the Lesser Antilles including interations with marine mammals and other top predators. FAO/Government Cooperative Programme FI:GCP/RLA/140/JPN Technical Document 7, 77 pp.

Hubert, P. 2002. Review of the social and economic status of the flyingfish fishery in Saint Lucia. Pp. 120-127, *in:* FAO (ed.). Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Bridgetown, Barbados, 8-12 January, 2001. *FAO Fisheries Report*. No. 670.

Hunte, W., Oxenford, H.A. & Mahon, R. 1995. Distribution and relative abundance of flyingfish (Exocoetidae) in the eastern Caribbean: II Spawning substrata, eggs and larvae. *Marine Ecology Progress Series,* 117: 25-37

Hunte, W., Mahon, R. & Oxenford, H.A. 2007. Synopsis of biological characteristics of the flyingfish, *Hirundichthys affinis*, relevant to assessment and management. Pp. 51-54 *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Jardine, C. 2002. The fisheries sector of Saint Vincent and the Grenadines and the national economy. Pp. 128-132, *in:* FAO (ed.). Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report*. No. 670.

Joseph, W.B. 1996. Small coastal pelagics and flyingfish fisheries of Saint Lucia: National report. Presented at: CFRAMP small coastal pelagics and flyingfish workshop. 11–13 September, Grenada SSW/WP/11, 7pp.

Khokiatiwong, S., Mahon, R. & Hunte, W. 2000. Seasonal abundance and reproduction of the fourwing flyingfish, *Hirundichthys affinis*, off Barbados. *Environmental Biology of Fishes*, 59: 43–60.

Lawrence, N.H. 2007. The flyingfish fishery of Dominica. Pp. 9-12, *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Lewis, J.B., Brundritt, J.K. & Fish, A.G. 1962. The biology of the flyingfish, Hirundichthys affinis. *Bulletin of Marine Science in the Gulf and Caribbean,* 12:73-94

Mahon, R., Oxenford, H. & Hunte, W. 1986. Development strategies for flyingfish fisheries of the eastern Caribbean. Proceedings of an IDRC-sponsored workshop at the University of the West Indies, Cave Hill, Barbados, 22-23 October, 1985. ICRC-MR128e, International Development Research Agency (IDRC), Ottawa, Canada, 148 pp.

Mahon, R. 1993. Lesser Antilles. Pp. 1-98, *in*: FAO (ed.). Marine fishery resources of the Antilles: Lesser Antilles, Puerto Rico and Hispaniola, Jamaica, Cuba. *FAO Fisheries Technical Paper* 326.

Mahon, R. 1996. Fisheries of small island states and their oceanographic research and information needs, pp. 298-322 *in:* Maul, G.A. (ed) Small islands: marine science and sustainable development. Coastal and Estuarine Studies 51, American Geophysical Union, Washington.

Mahon, R. 1989. Developing a management strategy for the flyingfish fishery of the eastern Caribbean. Proceedings of the Gulf and Caribbean Fisheries Institute 39: 389-402.

Mahon, R., Khokiattiwong, S. & Oxenford, H.A. 2000. Selectivity of experimental gillnets for fourwing flyingfish, *Hirundichthys affinis*, off Barbados. *Environmental Biology of Fishes,* 59: 459-463.

Mahon, R., Parker, C., Sinckler, T., Willoughby, S. & Johnson, J. 2007. The value of Barbados' fisheries: A preliminary assessment. Fisheries Division, Ministry of Agriculture and Rural Development, Barbados, Fisheries Management Plan Public Information Document 2, 24 pp.

Maul, G.A. 1993. Climate change in the Intra-Americas Sea. E. Arnold, London, 389pp.

Medley, P., Caesar, K., Hubert-Medar, P., Isaacs, K., Leslie, J., Mohammed, E., Oxenford, H.A., Parker, C., Phillip, P., Potts, A.C., Ryan, R. & Walters R. 2009. Management summary and stock assessment report for flyingfish in the eastern Caribbean Pp. 8-26, *in:* FAO (ed). Report of the Third Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Mt Irvine, Tobago, 21-25 July, 2008. *FAO Fisheries Report.* No. 929.

Mohammed, E. 1996. Small coastal pelagics and flyingfish fisheries in Trinidad and Tobago: National report. Presented at: CFRAMP small coastal pelagics and flyingfish workshop. 11–13 September, Grenada SSW/WP/13, 17pp.

Mohammed, E., Vasconcellos, M., Mackinson, S., Fanning, P. Heileman, S. & Carocci, F. 2008. A trophic model of the Lesser Antilles pelagic ecosystem. Scientific basis for ecosystem-based management in the Lesser Antilles including interactions with marine mammals and other top predators. FAO/Government Cooperative Programme FI:GCP/RLA/140/JPN Technical Document 2, 168 pp.

Morris, K. 2007. The flyingfish fishery of St. Vincent and the Grenadines. Pp.29-32, *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Murray, P.A. & George, S. 2007. The flyingfish fishery of St. Lucia. Pp. 23-27, *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Norman, N. 1999. The flyingfish fishery of Dominica. Pp. 16, *in:* FAO (ed.). 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.

Oxenford, H.A. 1985. Biology of the dolphin, *Coryphaena hippurus*, and its implications for the Barbadian fishery. Ph.D. thesis, University of the West Indies, Cave Hill, Barbados, 366pp.

Oxenford, H.A. 1994. Movements of flyingfish (*Hirundichthys affinis*) in the eastern Caribbean. *Bulletin of Marine Science,* 54: 49-62.

Oxenford, H.A. 2007. Summary of the importance of flyingfish fisheries in the eastern Caribbean. Pp.47-48, *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Oxenford, H.A. & Hunte, W. 1999. Feeding habits of the dolphinfish (*Coryphaena hippurus*) in the eastern Caribbean. Scientia Marina 63: 303-315.

Oxenford, H.A., Mahon, R. & Hunte, W. 1993. The Eastern Caribbean Flyingfish Project. *OECS Fishery Report* 9, OECS Fishery Unit, Kingstown, St. Vincent, 171 pp.

Oxenford, H.A., Hunte, W., Deane, R. & Campana, S.E. 1994. Otolith age validation and growth rate variation in flyingfish (*Hirundichthys affinis*) from the eastern Caribbean. *Marine Biology,* 118: 585-592.

Oxenford, H.A., Mahon, R. & Hunte, W. 1995a. Distribution and relative abundance of flyingfish (Exocoetidae) in the eastern Caribbean: I Adults. *Marine Ecology Progress Series,* 117: 11-23.

Oxenford, H.A., Mahon, R. & Hunte, W. 1995b. Distribution and relative abundance of flyingfish (Exocoetidae) in the eastern Caribbean: III Juveniles. *Marine Ecology Progress Series,* 117: 39-47.

Oxenford, H.A., Mahon, R. & Hunte, W. (eds). 2007a. Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados. 268pp.

Oxenford, H.A., Mahon, R. & Hunte, W. 2007b. Summary of stock assessment of *Hirundichthys affinis*. Pp. 253-258 *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Parin. 2002. Exocoetidae – flyingfishes. Pp.1116–1134, *in:* K.E. Carpenter (ed.). The living marine resources of the Western Central Atlantic. Volume 2, Bony Fishes Part 1, FAO Species Identification Guide for Fishery Purposes and American Society of Ichthyologists and Herpetologists Special Publication No. 5.

Parker, C. 1999. Developments in the flyingfish fishery of Barbados. Pp. 11–15, *in:* FAO (ed.). 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.

Parker, C. 2002. Developments in the flyingfish fishery of Barbados. Pp. 76–93, *in:* FAO (ed.). Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report*. No. 670.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons*. CIEM 39: 175-192.

Phillip, P.E. & Rennie, J. 2007. The flyingfish fishery of Grenada. Pp. 13–16, *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Potts, A.C., Thomas, A., Nichols, E., Lovelace, B. & Henry, L. 1999. The flyingfish industry of the Republic of Trinidad and Tobago. Pp, 27-39, *in:* FAO (ed.). 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.

Potts, A.C., Thomas, A. D. & Nichols, E. 2002. An economic and social assessment of the flyingfish (pelagic) fishery of Tobago, Trinidad and Tobago. Pp. 133–145, *in:* FAO (ed.). Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report.* No. 670.

Prescod, S. 1996. Report on the small coastal pelagics and flyingfish fisheries in Barbados. Presented at: CFRAMP Small Coastal Pelagics and Flyingfish Workshop. 11–13 September, Grenada SSW/WP/04, 20pp.

Rennie, J. 1999. National report for Grenada. Pp. 17-21, *in:* FAO (ed.). 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.

Rennie, J. 2002. Review of the social and economic status of the flyingfish fishery in Grenada. Pp. 103-115, *in:* FAO (ed.). Report of the Second Meeting of the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean, Bridgetown, Barbados, 8–12 January, 2001. *FAO Fisheries Report*. No. 670.

Samlalsingh, S. & Pandohee, E. 1992. Preliminary stock assessment for the flyingfish fishery of Tobago. Technical Report of the Project for the Establishment of Data Collection Systems and Assessment of the Fisheries Resources. FAO/UNDP: TRI/91/001/TR11. Port of Spain, Trinidad, 41 pp.

Samlalsingh, S., Pandohee, E. & Caesar, E. 2007. The flyingfish fishery of Trinidad and Tobago. Pp.33-45, *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

Storey, K.W. 1983. Aspects of the biology and fishery of the flyingfish, *Hirundichthys affinis*, at Barbados. MPhil Thesis, University of the West Indies, Cave Hill, Barbados, 161 pp.

Straker, L. 1999. The flyingfish fishery of St. Vincent and the Grenadines. Pp. 26, *in:* FAO (ed.). 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.

Welch, P.L.V. 2005. Exploring the marine plantation: an historical investigation of the Barbados fishing industry. *Journal of Caribbean History,* 39: 19–37.

Willoughby, S. 2007. The flyingfish fishery of Barbados. Pp. 2-8, *in*: Oxenford, H.A., R. Mahon and W. Hunte (eds.) Biology and management of eastern Caribbean flyingfish. Centre for Resource Management and Environmental Studies, UWI, Barbados.

This report provides a summary of the proceedings of the third meeting of the Western Central Atlantic Fishery Commission Ad Hoc Flyingfish Working Group of the Eastern Caribbean. It is organized into four parts. Part I contains a summary of the deliberations and results of the flyingfish stock assessment undertaken at the meeting. Part II gives a management summary and full technical details of the assessment. Part III presents national reports detailing data preparation. Finally, Part IV includes the amended subregional fisheries management plan for flyingfish in the eastern Caribbean.

ISBN 978-92-5-106570-9 ISSN 2070-6987

9 789251 065709

I1602E/1/05.10/900