BUILDING SCIENCE CAPACITY AND UNDERSTANDING AMONG IOTC CPCS

PREPARED BY: IOTC SECRETARIAT, 26 NOVEMBER, 2013

PURPOSE

To provide the Scientific Committee with an opportunity to note the science capacity building activities tentatively planned by the Secretariat in 2013 and 2014, as tentatively agreed to by the SC in 2012.

BACKGROUND

At its 15th Session in 2011 and 16th Session in 2012, the Commission agreed to further support capacity building activities among its Members by implementing adequate capacity building and support programmes.

As a result, the Secretariat is developing course outlines on four core topics:

- Connecting science and management in the IOTC process
- Basic stock assessment training
- Advanced stock assessment courses with IOTC Member countries and international experts
- Experimental design, analysis of ecological data and computational methods in quantitative ecology focussed on CPUE standardization

The target audience for these workshops will vary depending on the topic, from national scientists to middle managers who support IOTC Commissioners, from developing coastal states in interpreting scientific advice from the SC.

RATIONALE

Despite the importance of fisheries to the Indian Ocean region, scientific monitoring and management are modest, with most stocks lacking modern scientific stock assessments. Without stock assessments, it's impossible to determine whether fish populations are overexploited or, potentially, underexploited relative to their ability to support sustainable yields. At a national level, fishery yields have been flat over the past decade, while the Indian Ocean countries populations have increased, and thus the need for sustainable protein sources has continued to increase. Does the current plateau in fishery yields represent the maximum sustainable yield or is greater harvest possible? If higher yields are possible, do we get there by fishing harder or by rebuilding overfished stocks?

From a scientific perspective, India and other Indian Ocean countries fisheries represent an opportunity to learn about the success and failure of fishery management strategies across a wide diversity of scales and management approaches. Indian Ocean fisheries range from large-scale industrialized fisheries for pelagic fishes like oil sardine, herring, and tuna to artisanal fisheries for nearshore and estuarine species. No single management approach is likely to be effective at all scales. A growing body of research on small scale and artisanal fisheries suggests that despite the lack of traditional top-down management by the central government, many of these fisheries have managed to avoid the "tragedy of the commons" problem where common-pool resources are inevitably degraded (Feeny et al. 1996; Ostrom et al. 1999). At the same time, recent work on community co-management, a widespread approach to management of small-scale fisheries, has elucidated the characteristics of such systems that lead them to be effective (Gutierrez et al. 2011).

There is currently a lively scientific debate about the global status and trends of marine fisheries. The most recent evaluations suggest that, at a global level, populations of exploited marine fish and invertebrate have declined 38% between 1970 and 2007, but have, on average, been stable since the early 1990s (Hutchings et al. 2010). Approximately two-thirds of marine fish populations are currently below the population size that would produce the maximum sustainable yield, but only one-third of marine fish populations are now being fished at rates that will lead to depletion below this level (Worm et al. 2009). That is, for many overfished populations, fishing has been

reduced and the stage is now set for their recovery. These conclusions have been criticized[1] for their reliance on a global stock assessment database (Ricard et al. *In press*) in which fisheries from developing countries are seriously under-represented. The developers of that database, the only one of its kind, acknowledge this weakness but are limited by the existence and public availability of fisheries data from developing countries like India.

These capacity building initiatives will improve fishery management in the Indian Ocean region, while at the same time increasing our understanding of status and trends of fisheries in developing countries. The data which will be used in these stock assessments already exist, and the work of this project is synthesis, analysis, and capacity building.

Prior Experience and Relevant Capabilities of Principal Investigator.

Dr. Rishi Sharma, has extensive experience in stock assessment. He has an MS and a Ph. D. in Quantitative Ecology and Resource Management for the University of Washington and has been working with Indian Ocean countries in the region developing integrated stock assessment models. He has also run multiple workshops in the region assessing the data quality and usability within these countries, and has given specialized training on stock assessment within these countries. The project will build on his and other Indian Ocean Region scientists' current knowledge of information in the region, and help develop a mutually beneficial workshop that will help the scientists/academics/students in the region and help the larger understanding of global fisheries resources from the Indian Ocean Region as well.

Project Scope and Objectives

The ultimate objective of this set of courses is to give the coastal states and member countries of the IOTC to have the ability to understand the assessments, their implications, weakness, and assumptions. In the long-term, this will build a local pool of stock assessment scientist that will be able to interact in a more productive manner with the IOTC WP meetings, as well as improve the current level of understanding in fisheries in their respective countries. Thus, the primary objective is:

(1) Building regional knowledge with IOTC member country scientists and policy makers to interact in WP and Commission meetings at a higher productivity level.

As, we are undertaking these exercises in the region, we can request member countries to bring real- world data that they have collected to analyze within a series of workshops. Thus, on a secondary level the following objectives may also be met; Understanding the impact of fisheries on the populations they target is one of the fundamental goals of stock assessment. Without such an understanding, it is impossible to manage fisheries toward any sort of optimum, such as the maximum sustainable yield (MSY) or maximum economic yield (MEY). Data used on neritic tuna and other species of importance in the region for stock assessments conducted in workshops on this project will help answer two questions:

(2) How has the population size of fish and invertebrates targeted by fisheries in Indian Ocean Region changed through time?

(3) How does the current population size and level of fishing in Indian Ocean fisheries compare to the levels expected to result in MSY.

These questions will be addressed through a series of research and training workshops involving Indian Ocean fisheries scientists, fishery managers, and fisheries science graduate students, as well as internationally recognized experts on stock assessment. The specific fish and invertebrate populations targeted for these analyses will be

[1] http://blog.nature.org/2011/01/daniel-pauly-fish-stock-global-world-fisheries/

chosen by workshop participants, but will likely include Neretic tuna (Kawakawa, Longtail, bullet tuna, and King Mackerel for e.g.) as well as species which support small scale fisheries in the Indian Ocean Region. Assessments for some of these species already exist but they are generally focused on regional sub-components of the stock or use methods (e.g., yield-per-recruit analysis) with limited validity that do not produce time trends of abundance. All together, we anticipate conducting new assessments for 6-10 fish and invertebrate stocks.

Finally, an additional goal of the project is to understand and explain differences in status of different Indian Ocean fisheries. Global meta-analyses (Melnychuk et al. In press, Ricard et al. In press) suggest that regional differences in fisheries status are stronger than taxonomic differences or differences related to management approach. There is some indication that this is also true at a within-country level for larger countries like the U.S. and Canada (O.P. Jensen, unpubl. analysis). Higher trophic level fishes (predators at the top of the food chain) have been thought to be more susceptible to overexploitation, but a recent analysis (Pinsky et al. 2011) suggests that populations of small low trophic level fish collapse just as frequently, if not more. We will test these patterns within the wide variety of Indian Ocean fisheries. Thus, a final question to be addressed through a "management meta-analysis" of assessed fisheries in Indian ocean region, including those for which assessments already exist, and those to be assessed as part of this project:

4) What are the biological, management, and economic variables that distinguish "successful" Indian Ocean fisheries from less successful Indian Ocean fisheries?

Capacity Building Plan.

At the core of this project are different workshops which will include Indian Ocean fisheries scientists, fishery managers, students, and foreign fisheries stock assessment experts. The first workshop will be held in India/BOBLME country and will focus on data exploration and background briefing on the fisheries chosen for assessment as well as training students and fishery management agency personnel in stock assessment techniques. Fisheries chosen for assessment will be selected on the basis of (1) a need for new assessment because of, for example, economic importance or concerns over declining catches (2) availability of data to conduct a credible stock assessment. These data will likely include long-term trawl surveys conducted by countries in the region, and catch records maintained by the IOTC and Member countries in the Indian Ocean region.

The stock assessment training/course will be led by the PI and the International collaborator (Appendix B & C), both of whom have substantial experience training students in stock assessment techniques. Topics to be covered include: basic biomass dynamics models, delay-difference models, age structured models, and assessment approaches for data-poor stocks. Established Indian Ocean fisheries scientists familiar with the fisheries will be recruited to give lectures on the history of the selected fisheries with a focus on information most relevant to the assessments. Students will each select a fishery to be the focus of their stock assessment project, and they will begin their assessment during the workshop while the PI and U.S. collaborator are on hand to assist them.

The second training/course will build upon the first, and will train people on more advance principles in R and possibly programming (Material from Appendix B and C). The goal of this workshop/training is to combine information from the stock assessments begun during the first workshop as well as pre-existing stock assessments in a meta-analysis of the status and trends of Indian Ocean fisheries. The outputs from this workshop will include papers by the scientists on their species assessments to be published in a international fisheries journal and a report for distribution to policy makers in the region. A review paper on the results of all these assessments may also be submitted by the PI to assess the state of Indian Ocean stocks and fisheries of importance in the Indian Ocean Region.

A third type of course that is developed (appendix A) will focus on conveying this scientific information to policy makers so that they can make rational decisions in the Indian Ocean Tuna Commission Process. Middle managers,

Commissioners and scientists who need to understand the IOTC process (within the SC process) and how the management advice is produced, documented and presented in the reports of the WP's and the Scientific Committee; A fourth course (Appendix D) will cover basics of CPUE standardization techniques and how they should be conducted prior to the stock assessment model in which they will be used.

By the end of these workshops, managers and scientists should be confident in the interpretation of the information as presented in the species Executive Summaries. They should be able to interpret Kobe plots as well as the use decision tables for ranking possible actions. Participants should have a basic understanding of the limitations imposed by typical uncertainties, including limitations of the model formulations and consequences of poor data quality, and participants should understand the role of reference points and harvest control rules in managing resources under uncertainty.

One of the challenges of this project will be overcoming the reluctance of some fisheries agencies to make data publicly available. We believe that this reluctance stems largely from the "take the data and run" attitude that has been unfortunately common when foreign scientists seek data from agencies in developing countries. Our model is one of true collaboration, in which fisheries agency scientists will be full partners in this research and co-authors on the resulting journal publications. They will also benefit as their junior staff receive high-level training in stock assessment techniques. The agencies may still be unwilling to post their data to the publicly available portion of the stock assessment database. While we encourage them to be as open as possible with their data, we will accommodate concerns about open access by developing a limited-access section of the database, if needed.

References

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APPENDICES

Appendix A: Connecting science and management in the IOTC process

Appendix B: IOTC Basic/Advanced Stock Assessment Training with IOTC Member countries and International Experts

Appendix C: Experimental Design, Analysis of Ecological Data & Computational Methods in Quantitative Ecology

Appendix D: Statistical Methods for CPUE Standardisations

Appendix A
Connecting science and management in the IOTC process

Audience:

Middle managers and Commissioners who need to understand the IOTC process and how the management advice is produced, documented and presented in the reports of the WP's and the Scientific Committee;

Senior scientists who nevertheless might not be familiar with the formulation of advice in the format of the SC, and who often need to translate the advice into concrete recommendations for actions by their managers.

Objective of the course:

By the end of the workshop, managers should be confident in the interpretation of the information as presented in the species Executive Summaries.

They should be able to interpret Kobe plots as well as the use decision tables for ranking possible decisions.

Participants should have a basic understanding of the limitations imposed by typical uncertainties, including limitations of the model formulations and consequences of poor data quality

Participants should understand the role of reference points and harvest control rules in managing resources under uncertainty.

Contents

- Short description of the IOTC process
- Scientific analysis and formulation of management advice
- Basic models
- The basic data types used by the models; effects of problems in these data types
- Effects of errors (process and measurement) in the assessment
- Use of management advice in formulation of joint management actions in the presence of uncertainty: basic introduction
- Precautionary approach: reference points and harvest control rules
- What are acceptable levels of risk for management? (for managers)
- Constructing robust harvest control rules: Management Strategy Evaluation
- Communicating effectively the effects of uncertainty (for scientists)
- Implementation of management actions including data collection
- Effects of poorly implemented management actions

Format:

- 2-3 days
- Group of about 20 participants
- Presentations
- Review of a typical analysis: data issues, CPUE analysis, basic kinds of assessments.
- Group discussions on the basis of fictional or real case studies; role playing of managers and scientists
- What-if analyses: discussions of real population projections (could be done as a retrospective analysis)
- What-is-wrong analyses of real cases (e.g. the proposal for the hand-drawn Kobe plot)

Appendix B
IOTC Basic and Advanced Stock Assessment Training

Audience: Young scientists, mid-level and senior scientists who may not be familiar with stock assessment basics and first principles of analysis of fisheries data will be exposed to Surplus production, Yield per recruit, spawner recruit and age structured models.

Objective: The course is designed to introduce basic principles of stock assessment of tuna and tuna like species and how we may use data we collect to develop dynamic stock assessment models, understanding the assumptions used in the assessment and their effect on the outcomes. Course duration will be a week and cover the basics of assessment principles.

Course Overview
The objectives of this course are the following:

1) To understand basic concepts of population dynamics models and how to develop them on a species context for management.
2) The second part of the course is designed to introduce cutting edge computational tools to evaluate and understand how to collect and analyze data for ecological and environmental studies. This will primarily be done with the help of labs and tools in Excel and R.
3) An advanced version of this course will focus on programming, visualizing data, using integrated assessment models like SS-III and Multifan-CL. So, more in depth learning will occur on Topic 5 and 8 so that length based models are also included.

The course will cover the following topics in Stock Assessment:

1) Ocean habitats and species interactions
2) Life History and how they related to Population Dynamics
3) Sample Design: Designing useful data assessment systems
4) Population Dynamics Basics I (Yield per Recruit)
5) Population Dynamics Basics II (Age Structured Models)
6) Climate Forcing and Effects
7) Spawner and Recruit (SR)
8) Labs on SR, YPR and Age Structured models.
9) Labs for simple to complex Surplus Production to Age structured models (Computers will be needed for this).

Appendix C
Experimental Design, Analysis of Ecological Data & Computational Methods in Quantitative Ecology

Audience: Young scientists, Mid-level and senior scientists who may not be familiar with experimental design and approaches in population modeling and fisheries will be exposed to this topic. This will be a fairly long course (2 weeks) and cover a lot of linear modeling and stock assessment principles.

Objective: The course is designed to introduce cutting edge computational tools to evaluate and understand how to collect and analyze data for ecological and environmental studies. It will span two weeks in length and will include lectures and labs in sequence. The intent is to give scientists and managers the tools to analyze their own data, and eventually use these tools to develop their own skill sets. This course will cover computational methods in Ecological Modeling. Commonly used techniques in Applied Statistics will be covered, as well as some deterministic and stochastic models encountered in Mathematical Biology. While we cover the mechanics of doing various statistical analyses, the goal of the course is to develop the ability to use computational tools creatively to help visualize and grasp statistical concepts and modeled processes. There will be lots of emphasis on simulation and graphical visualization, since these are important tools in practice but scarcely touched upon in other courses.

Course Detail

Our primary tool will be **R and Excel (Microsoft)**. This is an object oriented language that is extremely powerful in analysis and design of data (http://www.r-project.org/- Ref: R Development Core Team (2007). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Each Day will consist of a lecture, an R lab and an assignment. One of the practical goals is to create a body of labs, assignments and datasets that can be used as a basis for a continuation of this course in years to come. All of these materials will be stored on a website.

There will be a final project involving some combination of analysis and presentation using R. These will be presented on the last day of class, i.e.: **Conference on Computational Methods in Quantitative Ecology .**

Course Overview (Lecture)

1) Lecture 0: Basic Introduction to R
2) Lecture 1: Distributions and the Central Limit Theorem
3) Lecture 2: Comparing two samples: Monte Carlo and t-tests
4) Lecture 3: Introduction to Analysis of Variance
5) Lecture 4: Linear Regression &Chi-squared Contingency Tables
6) Lecture 5 & 6: Generalized Linear Models
7) Lecture 7: Introduction to Stochastic Modelling
8) Lecture 8: Population Dynamics Models and MCMC
9) Lecture 9: Project Discussions
10) Lecture 10: Fitting models and optimization
11) Lecture 11: Final project presentations

Appendix D

Statistical methods for CPUE standardization (with Dr. Andy Cooper, SFU, Vancouver, Canada)

Audience: Young scientists, mid-level and senior scientists who may not be familiar with linear and non-linear statistical methods (frequentist, Information Theoretic, and Bayesian) used in CPUE standardization. Course size should be no more than 25 to allow for more one-on-one and group interactions. Ideal class size would be below 20.

Objective: The goal of this course is to teach students a wide range of quantitative methods applicable to the standardization of CPUE data. The purpose is to expose the students to the theory and application of these methods, give them hand-on experience using these methods, provide enough of a background so that they may begin to apply the methods on their own (and know when to ask for help!), and teach them interpret and apply the results for both scientific understanding and for the development of indices in stock assessment. We are aiming for more for breadth rather than depth, as there could be a full course designed for almost any of the topics we'll discuss.

Course Detail

Our primary tool will be the free statistical package **R** and the free **Rstudio** interface (http://www.rstudio.com/ide/). **R** is an object oriented language that is extremely powerful for data analysis and is commonly used in government and academia. (R Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.) Each student will need access to a computer (Windows, Mac, or Linux) for this course.

Each day will consist of a lecture, an R lab, and an assignment. The assignment will be based either on a dataset provided by the instructor or, if possible, data which students brought themselves. For each topic, when appropriate, students will explore hypothesis testing, Information Theoretic, and Bayesian approaches.

Ideally, there will be a final presentation during the last day of class in which students present the data they brought with them, the results of the various methods they applied, and a final determination for the standardized index of abundance.

Tentative Course Overview

Day 1: Probability distributions, likelihoods, and an introduction to R

Day 2: Hypothesis testing, (Q)AIC(c), Bayesian statistics

Day 3: Linear Regression

Day 4: Generalized Linear Models

Day 5: Hurdle models (e.g. delta-lognormal)

Day 6: Random/Mixed-effects models

Day 7: Generalized Additive Models

Day 8: Regression trees and Random forests (time permitting as these are advanced techniques)

Day 9: Final presentations and wrap-up based on datasets collected and assembled by participants.

TimeLine and Budget

January 2014– December 2014

Tasks	1	2	3	4	5	6	7	8	9	10	11	12
1. Prep Material				X	X					X	X	
2. Course 1: SA (western IO)SA Basics					X							
3. Course 2: SA II (eastern IO)											X	
Communication Science												
4. Progressive report orally and/or in a												X
written format at SC												

PROPOSED BUDGET (PROJECTED)

Capacity building / Regional training course on Stock Assessment (2 workshops)- Thailand BKK/HKT: Eastern Indian Ocean				
EXPERT-JIM IANELLI				
Travel	Air ticket	1	5,000	5,000
Subsistence & Accommodation - 7 days	Day	7	226	1,582
Sub-total				**6,582**
Participants				
Travel (20 pax)	Air ticket	20	800	16,000
Subsistence & Accommodation - 20 pax – 7 days (including resource persons)	Day	140	226	31,640
Travel-IOTC Scientist+DSA (7 days at 226/day)	Air ticket	1	5000+1582	6582
Training room & contingencies		1	5,000	5,000
Training materials (Training Material)		1	5,000	5,000
			TOTAL	**70,804**

Note if we do this in Phuket, we may save on room charges as we can do it at the Andaman Sea Centre and save on DSA $204/day so we are looking at ~10K less.

Capacity building / Regional training course on Stock Assessment (2 workshops)- Mauritius/Oman: Western Indian Ocean				
EXPERT-?? Olaf Jensen, Andy Cooper, Alejandro, Iago?				
Travel	Air ticket	1	5,000	5,000
Subsistence & Accommodation - 7 days	Day	7	260	1,820
Sub-total				**6,820**
Participants				
Travel (20 pax)	Air ticket	20	800	16,000
Subsistence & Accommodation - 20 pax – 7 days (including resource persons)	Day	140	260	36,400
Travel-IOTC Scientist+DSA (7 days at 226/day)	Air ticket	1	5000+1820	6,820
Training room & contingencies		1	5,000	5,000
Training materials (Training Material)		1	5,000	5,000
			TOTAL	**$76,040**

- Note if we do this in Oman the DSA is substantially higher at $356/day or Mombasa at $167/day. Mombasa will save us ~ $16000 versus Oman will add ~ 15,000 to the budget

Locations:

1) Eastern IO- Phuket, Thailand, May 21st-25th: Praulai has indicated she will make arrangements (BOBLME partners will pay travel of majority of participants).
2) Western IO- TBD (Dates Nov 26th-30th)