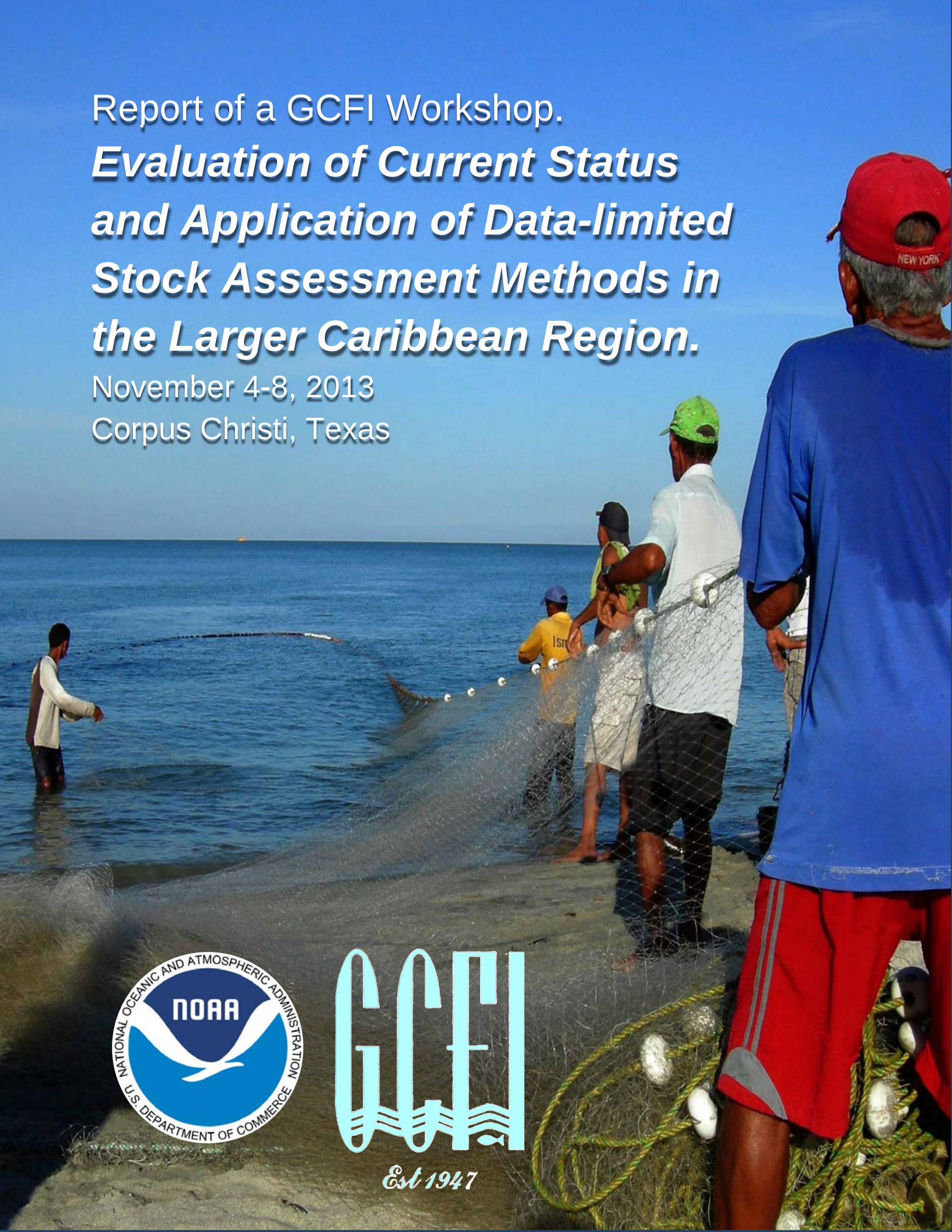
Report of a GCFI Workshop.

Evaluation of Current Status and Application of Data-limited Stock Assessment Methods in the Larger Caribbean Region.

November 4-8, 2013

Corpus Christi, Texas



NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

GCFI

Est 1947

Report of a GCFI Workshop.

Evaluation of Current Status and Application of Data-limited Stock Assessment Methods in the Larger Caribbean Region.

Hosted by the

66th Gulf and Caribbean Fisheries Institute Conference

November 4-8, 2013

Corpus Christi, TX

Nancie J. Cummings, Mandy L. Karnauskas, William L. Michaels, and Alejandro Acosta, Editors

Document should be cited as:

Cummings, N. J., M. Karnauskas, W. L. Michaels, and A. Acosta (editors). 2014. Report of a GCFI Workshop. Evaluation of Current Status and Application of Data-limited Stock Assessment Methods in the Larger Caribbean Region. Gulf and Caribbean Fisheries Institute Conference, Corpus Christi, Texas, November 4-8, 2013.

Sponsored by:

National Oceanic and Atmospheric Administration (NOAA) grant number NA13NMF4720236 was submitted by the Gulf and Caribbean Fisheries Institute and funded by the National Marine Fisheries Service's Office of Science and Technology. The Gulf and Caribbean Fisheries Institute hosted the workshop and special session on the evaluation and application of data-limited stock assessment methods in the larger Caribbean region.

Disclaimer:

The views expressed herein do not necessarily represent those of the National Marine Fisheries Service or Gulf and Caribbean Fisheries Institute.

The cover photo is an example of artisanal fishing along the coast of Santa Marta, Colombia. Photographs were provided by William Michaels.

Acknowledgements

This workshop was made possible by the Board of Directors of the Gulf and Caribbean Fisheries Institute (GCFI), a NOAA grant submitted by the GCFI, and financial support by the National Marine Fisheries Service (NMFS) Office of Science and Technology. Robert Glazer and Alejandro Acosta deserve acknowledgement for the NOAA grant submission and organizational assistance in hosting the data-limited assessment special session and workshop at the 66th GCFI Conference meeting held in Corpus Christi, Texas during November, 4-8, 2013. We are also thankful to Dr. Elizabeth Babcock, from the University of Miami, for providing the invitational keynote presentation. Nancie Cummings and Mandy Karnauskas from the NMFS Southeast Fisheries Science Center and Bill Michaels from the NMFS Office of Science and Technology served as the Conveners for the GCFI special session and workshop. Tara Dolan assisted as rapporteur to summarize the workshop minutes. Translation from English to Spanish was conducted by Emilia Cortes Gomez.

Table of Contents

	Page
Executive Summary	1
Background	2
Welcome and Introductions	3
Overview and Goals	3
Pre-workshop Questionnaire	6
Terms of Reference	7
Invited Speaker	8
Speed Presentations	9
Depletion-corrected average catch model (DCAC)	*9*
Density-control ratio rule	*10*
Statistical catch-at-length model (SCALM)	*11*
Length-based indicators in Bayesian framework	*11*
Uncertainty in length-based estimates of status	*12*
Nearly data-less management	*13*
MSC risk-based framework	*13*
Generalized Fisheries Simulation Model (FISMO)	*14*
Breakout Group Prioritization Activity	*15*
Breakout Group Sessions	16
Synthesis Discussions	19
Closing Statements	22
Appendix 1: List of oral presentations of the GCFI special session	23
Appendix 2: Participant list during GCFI data-limited assessment workshop	24
Appendix 3: Agenda of GCFI data-limited assessment workshop	25
Appendix 4: Pre-workshop survey questionnaire	26
References	27

Executive Summary

A special theme session and workshop on data-limited assessment methods were held at the 66th annual conference of the Gulf and Caribbean Fisheries Institute (GCFI) in Corpus Christi, Texas during November 4-8, 2013. Contributors to the GCFI special session provided presentations on a variety of analytical approaches that can be applied to data deficient stock assessments of living marine resources in the wider Caribbean region, and other similarly under-sampled habitats.

The one-day GCFI workshop provided an opportunity for scientists, managers, and stakeholders to examine the use of some analytical methods used in data-limited stock assessments, and approaches that identify the sources of uncertainty in these assessments. A pre-workshop questionnaire survey was employed to obtain information on the availability of the data-limited tools and the priorities of international scientists, managers, and constituents in applying these tools to data deficient situations in fishery management.

The participants evaluated these methods, and addressed key questions on what practices are currently being used to minimize uncertainty in data limited assessments. Participants evaluated the minimum data requirements for conducting data-limited assessments with each tool during the workshop.

The workshop participants highlighted the key attributes of the methods that can potentially be applied to diverse types of stocks, and prioritized recommendations based on the degree of effort and potential impact for improving data-limited stock assessments in the Caribbean region.

Background

This special workshop was proposed as one of a series of workshops to assist in the need to build scientific capacity in the wider Caribbean region through improved data-deficient stock assessment methods and more efficient data collections. The workshop was hosted by the Gulf and Caribbean Fisheries Institute (GCFI). Since the late 1940's, GCFI has served as an international forum among the scientists and managers who strive to improve the ecological health and socioeconomic sustainability of living marine resources in this region. Funding for the workshop was provided by the National Marine Fisheries Service (NMFS) with the recognition that the commercially and recreationally important fisheries have significant connectivity across the many international jurisdictions of this region. The overarching theme for this workshop, and subsequent workshops that build upon this work, is to develop an international collaborative effort to improve the availability, quality and timeliness of scientific information used in stock assessment, including the appropriate inferences drawn from this information.

… the need to build scientific capacity in the wider Caribbean region through improved data-deficient stock assessment methods and more efficient data collections.

Modeling is important for both forecasting and guiding data requirements; therefore it is appropriate that the first workshop begins with

an identification and evaluation of the modeling methods that can be applied to data-limited situations most often found in the wider Caribbean. In the Gulf of Mexico and Caribbean regions, survey capabilities are challenged by the size and diversity of the resource area, costs of conducting survey operations, biases associated with sampling gear, complexities in life history patterns of marine organisms, and difficulties in sampling habitats that are inaccessible and vulnerable to conventional sampling gear such as trawls. The difficulties of managing these subtropical marine resources are further complicated by the environmental effects on the marine ecosystem, diversity of fisheries and political complexity across jurisdictional boundaries.

Stock assessments in this region often do not provide sufficient information with which to effectively manage fisheries, and some of these concerns were highlighted during presentations provided during the GCFI special session entitled "Evaluation and Application of Data-limited Stock Assessment Methods" (*Appendix 1*). Under the scope of this theme session, this workshop provided an opportunity for improvements in the scientific information through the evaluation and recommendations in data-limited assessments used in the larger Caribbean region. The workshop was by no means a comprehensive overview of all of the existing data-poor stock assessment methods. For such summaries, readers should refer to the results of previous workshops, as well as the literature (e.g., (Caribbean Fishery Management Council, 2011; Pilling, et al., 2009; Honey, Moxley, & Fujita, 2010).

During the workshop, discussions included the utilization of the presented data-limited tools, and need to develop new collaborations amongst the participants to further improve the tools to address data-deficient fisheries stock assessments in the wider Caribbean.

Welcome and Introduction

The conveners thanked the presenters for contributions to the GCFI special session on data-limited stock assessments *(Appendix 1)*, and welcomed the participants *(Appendix 2)* to this GCFI data-limited stock assessment workshop. It was noted that the attendees represented a diverse group of fishery scientists, natural resource managers, fishers, and non-governmental organizations from various countries throughout the Caribbean region. This collaborative effort is considered critical for guiding the political will through consensus building among scientists, managers, and stakeholders in directing wise investments for improving scientific information, including the need to evaluate the appropriate analytical tools to address data-limited challenges in this region.

A general outline of *the* workshop agenda was reviewed *(Appendix 3)* and there was agreement that the workshop structure would continue to build on the oral presentations given earlier during the formal GCFI symposium *(Appendix 1)*.

Overview and Goals

The ability to conduct stock assessments in the Caribbean region is often limited by insufficient data collections, such as having only short time series of catch and length data. Regardless of these data deficient situations, managers must still make policy decisions to maintain the sustainability of the marine resources such as fisheries. This workshop provided the opportunity to evaluate the low spectrum of data-poor assessment methods.

The ability to conduct stock assessments in the Caribbean region is often limited by insufficient data collections …

Our challenge will be to define the minimum data requirements for these data-limited analytical approaches, how to characterize uncertainties in these methods, and their applicability for managers. Workshop conveners provided a brief overview of the workshop goals and expected products.

Participants agreed on the following workshop goals:

i. **Identify primary assessment tools currently in use by country, and resource type.**
ii. **Identify data-limited assessment techniques, the data needs and understand the challenges related to each assessment type.**
iii. **Outline potential synergistic relationships which could result in immediate improvements to stock assessments (e.g., technical capacity to improve biological data collections, analytical tools, and expertise among the countries within the region).**

This workshop is viewed as the first in a series of GCFI workshops that build upon each other to achieve the ultimate goal of building scientific capacity to achieve sustainable fishery resources and healthy marine ecosystems in the wider Caribbean regions, and this includes the fundamental requirement of improving data monitoring programs and analytical tools.

Therefore, participants should consider themselves as a study group who will continue to work on this effort beyond this workshop and help guide the direction of the following workshops that will address fisheries-dependent and fisheries-independent data requirements.

Table 1. Categories of tools for improving data-limited stock assessments presented during the GCFI special session; the list of presentations from the GCFI special session is provided in *Appendix 1.*

Method category	Examples
Quantitative biomass-based methods	Depleted Correction Average Catch (MacCall, 2009) MSY from catch (Martell & Froese, 2012) Density-based methods
Quantitative length-based methods	P_{mat}, P_{opt}, P_{mega} (Froese, 2004) P_{obj} (Cope & Punt, 2009)Mortality estimators (Ehrhardt & Ault, 1992; Gedamke & Hoenig, 2006) Length-based ecosystem indicators (Shin, Rochet, Jennings, Field, & Gislason, 2005) Length-based CPUE decision trees (Prince, Dowling, Davies, Campbell, & Kolody, 2011; Wilson, Prince, & Lenihan, 2010)
Semi-qualitative methods	Participatory Fisheries Stock Assessment (Walmsley, Medley, & Howard, 2005) "Robin Hood" approach
Assessment support tools	Productivity and Susceptibility Assessment (PSA) Spawning Aggregation Monitoring Protocol (Heyman & Adrien, 2006)

Pre-workshop Questionnaire

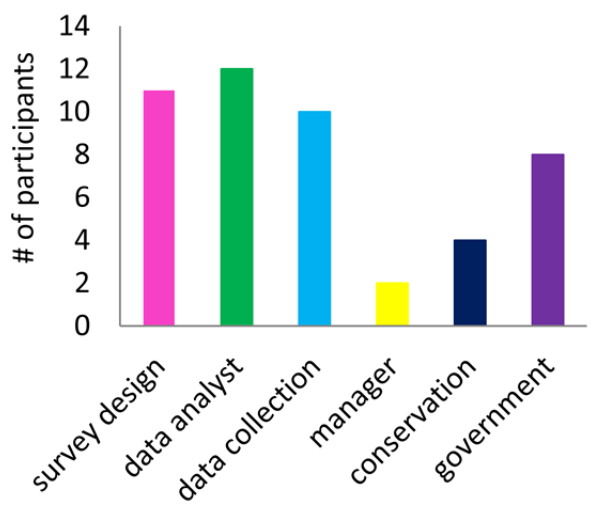
Prior to this GCFI workshop, a questionnaire survey *(Appendix 4)* was distributed to query experts in stock assessment, survey operations, and technology, as well as resource managers, on the ongoing developments and challenges relevant to data limited stock assessments within the larger Caribbean region. Responses to the questions would inform the final structure of the workshop.

The focus questions revolved around primary issues such as:

i. **Identifying the primary fisheries by country,**
ii. **Identify type of management and/or stock assessment procedures in use,**
iii. **Identify the relevant data types (e.g., fisheries-dependent catch and landings data, and fisheries-independent data) primarily utilized by the assessments,**
iv. **Identify primary gaps in information causing uncertainty in the assessments,**
v. **Identify the quantity and relative quality of information currently available by country, resource group) for the primary fisheries that could be used for a workshop to conduct an evaluation exercise using data-limited analytical methods.**

A summary of the pre-session questionnaire responses were presented in the beginning of the workshop to open discussions among the participants on the terms of reference and objectives of the workshop and break-out group activities. Most of the questionnaire submissions were from experts on survey design, data analysis or data collection background (Fig. 1).

Figure 1. Participant responses to the question: In what capacity are you involved with fisheries management?



The survey participants were comprised of fishery scientists and managers from various governments, non-governmental organizations, and academic institutions. When asked what they wished to achieve in the workshop, the most popular goal was to learn new tools in the realm of data-limited assessments. Other participants wanted to share tools, and collaborate with others in the development of the data limited stock assessment tools (Fig. 2).

When survey participants were asked if they would be interested in engaging in collaborations after the workshop, the majority replied affirmatively (Fig. 3).

Figure 2. Participant responses to the statement: Briefly describe what you want to achieve by attending this workshop.

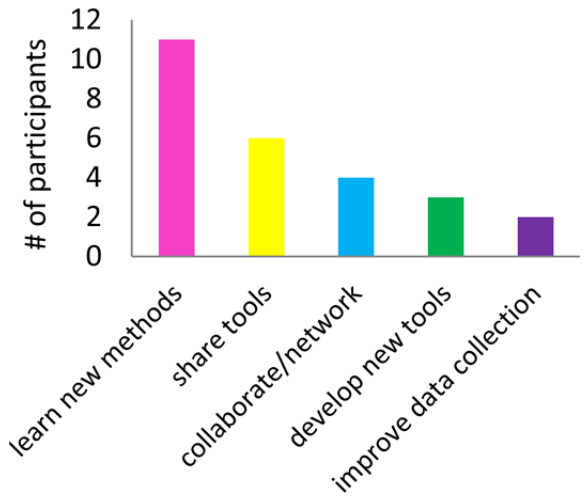
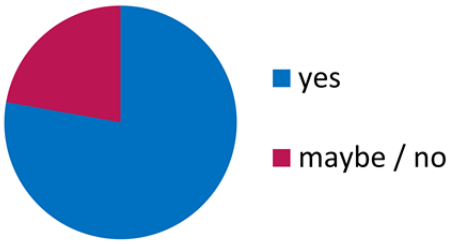


Figure 3. Participant responses to the question: Would you be interested in working together inter-sessionally (between annual GCFI conferences) with researchers from another region to assess a data poor fishery?



Terms of Reference

Upon the review of the pre-workshop questionnaire results and goals of the workshop, the workshop conveners introduced the terms of reference. After a brief discussion among the workshop participants, there was unanimous agreement on the following terms of reference.

Terms of Reference

i. **Identify data-limited stock assessment tools and methods currently in use in the region.**
ii. **Define the data needs and challenges related to each assessment tool.**
iii. **Identify synergistic relationships which may result in improvements to stock assessments.**
iv. **Provide recommendations for further improvement of data-limited techniques.**

Invited Theme Speaker

Dr. Elizabeth Babcock from the University of Miami, who had earlier in the week, provided the invitational keynote presentation for the GCFI special session on data limited assessment methods, gave a brief overview on the topic of data limited assessments and tools to the workshop participants. Dr. Babcock's talk included several aspects of the workshop's theme ranging from formulating data limited assessments to interpretation of results.

… we should match the models to the data and the questions of the managers and stakeholders.

Key points of Dr. Babcock's theme talk were: 1) how do we justify the use of data-poor models to managers and 2) we should match the models to the data and the questions of the managers and stakeholders. She explained that when using data-poor methods, scientists must conduct appropriate model simulations to understand the model performance and uncertainties, and evaluate the results from various models to ensure the most appropriate approach is used for each data-poor situation.

Subsequent discussion included the following:

i. **Identify data-limited approaches and the different outputs provide by each method.**
ii. **Analytical tools and outputs may range from qualitative to quantitative (Table 1).**
iii. **Categories of quantitative analytical tools (e.g., many are biomass based or length based).**
iv. **Methods requiring less rigid data input (e.g., semi-qualitative methods) can include decision support tools.**

Speed Presentations

Speed presentations, limited to five minutes, provided participants with a brief overview of the data-limited assessment tools, and these overviews formed the basis of the following breakout sessions and discussions. These specific tools were identified by the workshop participants through the pre-session questionnaire. Participants were queried in the pre-session questionnaire as to (1) what tools were in use and (2) would they provide a brief review of the tool in regard to data inputs, challenges and limitations. The following eight speed presentations were given.

1. Depletion-corrected average catch model (DCAC)

Claudia Friess presented on the depletion corrected average catch method (DCAC) developed by MaCall (2009). This method, available in the NOAA Fisheries Stock Assessment toolbox (http://nft.nefsc.noaa.gov/) uses inputs of historical catch time series, M and F_{MSY}/M, and B_{MSY}/B_0 as well as depletion of catch time series, to estimate a sustainable yield. The method uses minimal data inputs, but is not useful for species with very high natural mortality rates, and is sensitive to assumptions about the given delta depletion value.

Ms. Friess presented the method using Gulf of Mexico yellowedge grouper and red porgy examples. The DCAC method is related to depletion-based stock reduction analysis (DB-SRA) and a similar catch-based MSY method has been explored by the Gulf of Mexico Fishery Management Council (Martell & Froese, 2012).

There were discussions on the assumptions of DCAC model, such as the challenge of meeting the assumption that data adequately captures the entire range of a population. For example, this approach does not work well with red drum because difficulties with sampling their inner coastal distributions. There is the ability to bracket the depletion value to address the degree of uncertainty and understand whether you are getting better or worse, but clearly the limitation of catch data is the need for better length data. A length-based approach is likely the first method to begin with.

2. Density-control ratio rule

Dr. Beth Babcock presented on the density-ratio control rule method, which uses data from monitoring inside versus outside marine reserves to inform fisheries management. The method works via a control rule whereby reduced fishing is recommended if the density ratio between outside and inside the reserve falls below a certain level. The method is appealing from the perspective that it does not require large data sets, but rather can be applied when only minimal data inputs are available.

The method has been tested in a management strategy evaluation simulation (Babcock & MacCall, 2011). The method is advantageous in that it doesn't require size or age information, nor does it require baseline information. The method does require some assumptions to be made about adult movement, but larval dispersal is only an issue in situations where recruitment is inversely related to adult biomass.

It was recommended that management actions based on this the density-control ration rule method be introduced gradually and cautiously, to allow for the time lag needed for the reserve to take effect. During the density-control ratio rule presentation, an analogy was made to the conch fishery on Pedro Bank management which uses 'density per area' for management.

Additional discussion took place on the topic of what was an optimal procedure for obtaining a good (robust) estimate of density.

Discussions occurred on the recognition that this approach may work better for some species than others. The monitoring program should provide adequate density information, and the amount of larval dispersal will not be as important as movements of the adults. The advantage of this approach is the simplicity of making density ratio calculations. The disadvantage is the difficulties of obtaining unbiased density estimates from fisheries-dependent sampling programs.

3. Statistical catch-at-length model (SCALM)

Dr. Josh Nowlis developed the statistical catch-at-length model (SCALM) by adapting a length-based model (Williams & Shertzer, 2005) with the statistical catch at age methods.. The model uses growth and survival to estimate abundance and recruitment over time. Inputs include natural mortality, growth parameters, weight-length conversions, maturity changes at age, landings, length classes and abundance indices. However, not all of these data are needed, and much of these data can be obtained from unconventional sources.

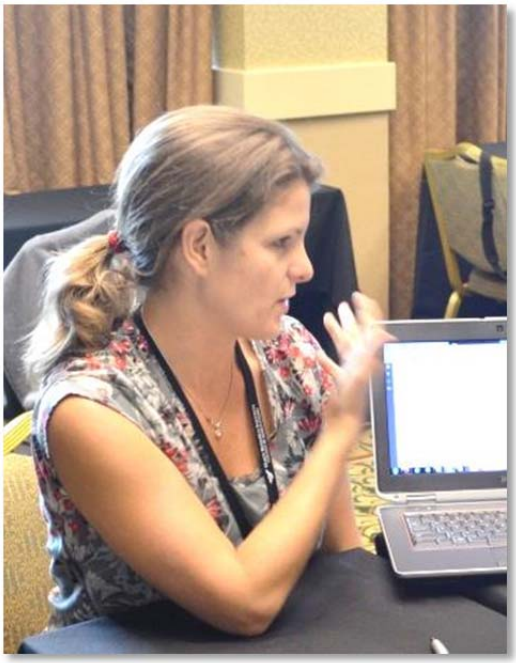
The SCALM model has been implemented in Excel and includes graphic outputs, and is accessible to individuals who do not have modeling backgrounds. It is less rigid than a surplus production model with regards to assumptions about stock-recruitment relationships, and can thus be advantageous when there is some size information from sources such as port sampling. There were discussions on the importance of conducting simulations to weigh data and evaluate stock recruitment relationships for stocks from different regions.

4. Length-based indicators in Bayesian framework

Dr. Mandy Karnauskas presented a Bayesian implementation of the community-level slope of the size spectrum indicator, which has been shown to serve as a potentially robust indicator of overall fishing pressure (Daan, Gislason, Pope, & Rice, 2005; Graham, Dulvy, Jennings, & Polunin, 2005) (Graham, Dulvy, Jennings, & Polunin, 2005). Given the assumption that fishing typically removes large individuals first (which may not always be true) a decreased slope in the log-transformed size spectrum of the community can indicate increased fishing pressure. Thus, the indicator can be used to give a reference direction, but not exact magnitude in reference points. The Bayesian implementation of the indicator allows for random variables to be incorporated into the calculation of slope, and also allows for quantification of variance around estimates of the slope.

An example was presented where the indicator was calculated based on an underwater visual survey data set, with habitat type and individual diver bias included as random variables. The Bayesian community-level slope estimator is available in WinBugs and an R version is under development. There was recognition that this approach allows for evaluation of a change in slope of length distributions to detect impacts from overfishing.

A population comprised of mainly smaller fish suggests to managers that a fishery may be over-exploited, but there may be difficulties with this conclusion for shorter time series that are less likely to detect recruitment from a strong year class. There were discussions on the uncertainties in length-based approaches and the benefits of bootstrapping of representative catch sampling.



5. Uncertainty in length-based estimates of status

Dr. Babcock presented an implementation of the length-based fishing indicators originally introduced by Froese (2004) and Cope and Punt (2009). Based on a representative sample of fish lengths from the catch, the indicators are used to determine whether individual species are overfished and/or experiencing overfishing. Input parameters for this approach include length at maturity, Von Bertalanffy growth parameters, natural mortality, and L_{opt}. These estimators assume equilibrium conditions.

Dr. Babcock conveyed the importance of understanding uncertainty in these estimates of management status which stems from the often poor estimates of life history parameters. Particularly for the data-poor reef species, the estimates of life history parameters can span a very broad range, which carries through to high uncertainty around estimates of management status. The estimators are implemented in the R software.

6. Nearly data-less management

Dr. Josh Nowlis presented an approach he developed, where a dynamic population model with logistic growth and a linear harvest function is used to calculate target biomass and catches under different management scenarios. The premise behind this approach is that managers pick a target harvest level where they decide how responsive they want management to be.

Dr. Nowlis described how management advice can be provided with care, in the absence of an accurate stock assessment. The advantage with this approach is it can be used for highly uncertain fisheries in minimal data situations. The beta model has a user interface and is available, but is still under development. Discussions emphasized the objective in data-limited situations is to use the appropriate simple model, and to determine the minimum data requirements to derive the reference points that managers need to address the harvest control mandates.

7. MSC risk-based framework

Dr. Monica Valle presented on the Marine Stewardship Council (MSC) risk-based framework (RBF) which is a set of assessment methods initially developed to address the assessment of data-deficient and small-scale fisheries. The two-tier approach first qualitatively assesses stakeholder information and then applies a semi-quantitative assessment based on the productivity and fishing susceptibility of a species. This method takes into account indicators such as stock status, environmental impacts, and management and governance, in determining susceptibility score for a given stock. Productivity of a stock is scored based on knowledge of the life-history of the species.

The method is useful to determine whether precautionary approaches are warranted, where there are insufficient data for a standard stock assessment. The RBF may be used for any fishery requiring fishery certification requirements. In principle, the less data available results in the RBF being more precautionary to avoid overfishing.

8. Generalized fisheries simulation model (FISMO)

Dr. Ernesto Chavez presented the Fisheries Simulation Model (FISMO), which was developed to address data-limited situations by reconstructing the age structured biomass of a population using publically available data from FishBase and FAO catch databases. The model was developed in EXCEL and relatively automated to use.

The advantages of the model are it is responsive to changes in age at first catch and fishing mortality, can be used to evaluate the impact of various exploitation rates on yield and catch composition, and incorporates economic parameters such as costs of fishing and profits per fisher. The model is freely available.

Breakout Group Prioritization Activity

Following the morning session of speed presentations on data limited tools, the conveners engaged the participants in an interactive activity that lead to the prioritization of assessment tools to be addressed by the breakout group. Workshop participants were asked to select their 1st and 2nd preferences of tools to further explore in a group (breakout) session. Participants were also instructed that each breakout group would be given a series of questions to be addressed for each tool. The questions were intended to provide a starting base for group discussions.

Questions discussed during the prioritization activity were:

1. ***What are the minimum inputs of this method?***
2. ***What sort of management advice is output from this method?***
3. ***What are the strengths and weaknesses of this method?***
4. ***What major assumptions are made in this method?***
5. ***What kind of software is used to implement the method?***
6. ***To what extent is it automated?***
7. ***Under what circumstances might this method be most useful?***

Breakout Group Sessions

The results from the group prioritization exercise were reviewed, and four data limited tools were selected by the workshop participants for the breakout group discussions. Following with a brief characterization of the data tool, the required inputs, and pros and cons of each tool, these attributes were categorized (Table 2) for four selected data-limited assessment methods.

Four data-limited assessment methods evaluated during the breakout group sessions:

1. ***Depletion-corrected average catch model (DCAC)***
2. ***Density-control ratio rule***
3. ***Size-distribution model (SCALM)***
4. ***Bayesian length-based indicators***

Table 2. Comparison of attributes for four of the methods discussed during the breakout group session.

(1) DCAC	(2) Density-control ratio rule	(3) SCALM	(4) Bayesian length-based indicators
minimum inputs			
- sum of catches over a period - estimate of M, F_{MSY}/M, B_{MSY}/B_0, and relative depletion (delta) over catch period	- lengths from representative sample of the community, preferably fishery-independent	- life-history parameters - observed age comps - catch - index of abundance	- L_M, L_{INF}, K, M - length-frequency sample of the catch
management advice output			
- level of catch that is likely to be sustainable (or range of likely sustainable catch)	- reference direction of overall fishing mortality	- total mortality - predicted landings - predicted length and age comps - SSB and S-R relationship	- status, overfished and/or experiencing overfishing
Strengths			
- minimal data input - don't need to know full catch history - ability to run Monte Carlo simulations - relatively robust to misspecification of M and F_{MSY}/M	- integrates over many species, community metric	- few inputs, or as many as available - gives sense of stock-recruitment relationship	- accounts for uncertainty in life-history parameter estimates - simple conceptually
Weaknesses			
- not necessarily good MSY proxy - sensitive to assumptions about depletion delta - doesn't work if M > 0.2	- no quantitative management targets	- no sensitivity or uncertainty measures	- assumes equilibrium
software used and (extent of automation)			
NOAA fisheries toolbox (high)	WinBUGS, R (low)	Excel (medium)	R (low)
additional considerations			
- need information to inform delta - any CPUE data, even qualitative or anecdotal information - managers should collect info (length and/or effort) to inform adjustments to DCAC-based catch limits			- length-frequency assumes it is representative of catch

After lunch, the workshop conveners re-convened the participants briefly to determine if the participants wanted to continue their morning breakout group discussions or enter into new groups. The participants wanted to continue developing their discussions. Table 2 summarizes the overall characterizations from the participants for the data limited tools considered during the workshop. During the group discussions, some participants also had a chance to work with their own data sets, or to obtain advice regarding whether certain methods were suitable for available data.

Synthesis Discussions

To stimulate more discussion and synthesis, another interactive exercise was carried out. Participants were asked to brainstorm answers to the question: "In the perfect world where money and time have no limitations, how would you improve data-limited assessments?" Participants were directed to disregard the perhaps most obvious answer – "*simply to get the necessary data to do traditional stock assessments*" – and to think about what actions would lead to improvements in the use of data-limited techniques.

Each participant were asked to identify their key recommendation for improving data-limited assessments in the Caribbean region, and then these recommendations classified within an Effort-Impact contingency table (Table 3). Each idea was scored on the amount of money or resources that would be required for the task to be accomplished (effort) and by the magnitude of improvement expected.

Table 3. The Effort – Impact contingency table used for categorizing recommendations for improving data-limited stock assessments from the workshop prioritization activity.

		Level of Costs/Resources	Level of Costs/Resources
Major Improvement	***Impact***	1. Easy / Major	3. Difficult / Major
Minor Improvement		2. Easy / Minor	4. Difficult / Minor
		Effort	

From this framework, action items are easily prioritized by the participants. For example, the recommendations that were placed in the "easy/major" effort/impact category could more readily be implemented and have the most impact with improvements, therefore should receive priority. After all participants had finished the categorization, the ideas in the Easy/Major section were reviewed as a group. Concrete, actionable ideas then formed the basis of further discussion and recommendations. The results from the prioritization exercise are presented in Table 4.

Table 4. Recommendations by degree of effort and impact from the 2013 GCFI data limited workshop group brainstorming activity.

Impact	1. Easy / Major • Couple ecological data collection into effective modeling. • Develop and use models suitable to the data available to take most value from it. • Integration of community-based methods with analytical methods. • Focus on length-frequency data with some CPUE, basic life history data, growth and longevity, nursery areas, reproduction. • Get length-frequency data annual for key species. • Have more workshops. • Gather basic life-history data from understudied regions. • Accurate catch and effort data time series. • Train existing technical staff at FMCs to conduct data-poor assessments to satisfy the need of setting species-specific ACLs (per MSA). • Reexamine application of the MSY concept, and particularly focus on the definition of OY that includes ecological, social, and economic considerations. • Construct a management advice section of the NFT to take common outputs and translate them into specific useful management advice about the tradeoffs we face.	3. Difficult / Major • Design and implement a good fishery-independent survey that collects relative abundance and length data which covers the stock throughout its range on a relevant spatial and temporal scale. • Put tools in a format accessible to all fishery managers. • Get updated age, growth and reproduction data.
	2. Easy / Minor/Moderate • Validate self-reported catch and effort statistics across various sectors.[1]	4. Difficult / Minor / Moderate N/A
	Effort	

[1]Note, adequate validation of catch and effort statistics dependent on sufficient funding to cover primary landing sites

It was interesting to note that most participants felt that their suggestions fell into the realm of easily implemented and major impact actions. When listed together however, it became clear that relative to one another, some of the actions would be more difficult to implement than others. For example, many of the suggestions were focused on gaps in data collections, which will need to be resolved through more efficient sampling and increased funding. Other suggestions focused on capacity building or integration of existing methods. The one suggestion that was labeled in the "easy/minor" category was considered to be a key recommendation to validate self-reported catch and effort statistics across various sectors in the Caribbean region. The wide variety of responses and the differing perspectives on what is easily and not easily achieved reflects the diversity of the workshop participants and the management culture of their home countries.

… a key recommendation to validate self-reported catch and effort statistics across various sectors in the Caribbean region.

Much of the discussion from the concluding activity focused on the overall lack of fisheries data, and need for improvements in data collection. Specifically, accurate catch and effort data, life history information, and length-frequency data were noted as lacking. It was noted that next year's GCFI workshop will focus on fishery-dependent data collection, and that some of the outputs of the current workshop

would feed into preparation for future work on the topic. Discussion also focused on building technical capacity, and constructing outputs that are useful for management. It was noted that data-poor stock assessment methods are seldom used, and that perhaps this signals an increased necessity for meshing the science with the needs of stakeholders. In relation to this, it was also mentioned that status metrics may need to be re-examined for data-poor methods, since many of the methods do not supply the typically used MSY-based benchmarks.

Two main action items were identified:

1. **Continued discussion in the interim on data collection improvements and protocols.**
2. **Exploration of a simulation approach to evaluate the performance of various data-poor methods.**

Several participants were interested in being involved with these initiatives and it was agreed that participants would keep in contact via e-mail during the interim.

Closing Statements

Concluding discussion revolved around the need to validate and endorse data-limited assessment approaches for the broader assessment community. In regard to implementing these data-limited assessment methods into regular practice, the point was brought up that "data-limited" is often considered to be synonymous with "less desirable." However, from a fishery management perspective, data-limited tools may be more desirable than complex stock assessments. This is especially true if they give the same answer without necessitating extensive data collection or model construction effort. The group's recommendation was to put greater consideration into finding the "right size model" for any particular stock assessment.

… need to validate and endorse data-limited assessment approaches for the broader assessment community.

A number of participants were interested in carrying out simulation work in order to validate or test some of the data-limited assessment tools. One idea was to carry out comparisons of data-rich and data-limited methods on stocks that have already been assessed with data-rich methods, and to investigate the minimum data requirements for each data-limited approach. Another idea was to test different approaches using a simulated fish population to understand the circumstances in which certain models perform better than others.

It was agreed upon that workshop participants would be contacted after the workshop with an invitation to collaborate on such efforts. Lastly, the workshop concluded with discussions on linking the results of this workshop with next year's proposed workshop, and the participants' recommendations will be incorporated into the proposal that have a focus on improving fisheries-dependent data for data-limited stock assessments.

Appendix 1. List of oral presentations of the GCFI special session entitled "Evaluation and Application of Data-limited Stock Assessment Methods" which was conducted in conjunction with this GCFI data-limited methods workshop.

Michaels, William. Building a collaborative strategy for the assessment of data deficient fisheries in the Caribbean region.

Babcock, Elizabeth. The influence of uncertainty in life history parameters on the estimation of status using low-data assessment methods.

Benson, Kristopher. Evaluating approaches for improving data-limited stock assessments across Caribbean jurisdictions.

Fujita, Rod. A framework for applying data limited analytical methods to fishery management.

Karnauskas, Mandy. Generating fisheries management advice in data-limited situations: examples from the U.S. South Atlantic and Caribbean.

Cooper, Wade. A modified catch survey analysis for assessing northern Gulf of Mexico blue crabs.

Keithly, Walter. Limitations associated with establishing a catch share program in a data poor fishery: a case study of the Puerto Rican deep water snapper fishery.

Nowlis, Josh. Casting deeper and more widely to perform stock-specific fisheries assessments when data are sparse.

Richardson, Laura. Cayman Islands Marine Protected Areas, enhancing a 27 year legacy.

Heyman, William. Let them come to you: Improving assessment and management of data poor fisheries in the snapper-grouper complex.

Pavlowich, Tyler. Using present-day details of coral-reef fishers' harvest, including taxonomic and size-structure, to support ecosystem-based fisheries management in Montecristi National Park, Dominican Republic.

These abstracts and manuscripts will be made available through the proceedings of the 66th Gulf and Caribbean Fisheries Institute Conference at *www.gcfi.org*

Appendix 2. Participant list during GCFI data-limited assessment workshop.

Last Name	First	Organization	Email address	
Acosta	Alejandro	Florida Fish and Wildlife	Alejandro.Acosta@myfwc.com	x
Appeldoorn	Richard	University of Puerto Rico	richard.appeldoorn@upr.edu	x
Babcock	Elizabeth	University of Miami	ebabcock@rsmas.miami.edu	x
Benson	Kristopher	NOAA Restoration Center	kristopher.benson@noaa.gov	x
Berkson	Jim	NOAA Fisheries	jim.berkson@noaa.gov	
Bush	Phillippe	Dept. of Environment, Cayman	Phillippe.Bush@gov.ky	
Chavez	Ernesto	IPN CICMAR, La Paz, México	echavez@ipn.mx	x
Cummings*	Nancie	NOAA Fisheries, Miami Lab	nancie.cummings@noaa.gov	x
Dolan	Tara	NOAA Fisheries, HQ	tara.dolan@noaa.gov	x
Dunmire	Leda	Pew Charitable Trust	LDunmire@pewtrusts.org	x
Ellis	Robert	Florida State University	rdellis@bio.fsu.edu	
Farchette	Carlos	Caribbean Fishery Management	carlosfarchette@gmail.com	x
Friess	Claudia	Ocean Conservancy	cfriess@oceanconservancy.org	x
Fujita	Rod	Environmental Defense Fund	rfujita@edf.org	
Goyert	Wendy	World Wildlife Fund	Wendy.Goyert@wwfus.org	x
Graham	Rachel	Wildlife Conservation Society	rgraham@wcs.org	
Granados-Dieseldorff	Pablo	Private	pablogd@tamu.edu	
Guillen	George	University of Houston	Guillen@uhcl.edu	x
Heyman	Will	LGL Research Associates	wheyman@lgl.com	
Hill	Ron	NOAA Fisheries, Galveston Lab	ron.hill@noaa.gov	x
Ingram	Walter	NOAA Fisheries, Pascagoula Lab	walter.ingram@noaa.gov	x
Karnauskas*	Mandy	NOAA Fisheries, Miami Lab	mandy.karnauskas@noaa.gov	x
Keithly	Walter	Louisiana State University	walterk@lsu.edu	
Lugar	Jay	Marine Stewardship Council	Jay.Lugar@msc.org	x
Matthews	Tom	Florida Fish and Wildlife	Tom.Matthews@myfwc.com	x
Mehaffie	Nicole	Chesapeake Biological Laboratory	nicole_mehaffie@ios.doi.gov	x
Michaels*	William	NOAA Fisheries, HQ	william.michaels@noaa.gov	x
Nowlis	Josh	Bridge Environment	jsnowlis@gmail.com	x
Olsen	David	St. Thomas Fishermen's	olsen41@aol.com	x
Pavlowich	Tyler	Dartmouth College	tyler.pavlowich@dartmouth.edu	x
Pitt	Joanna	Bermuda Dept. of Environmental	jpitt@gov.bm	x
Pollack	Adam	NOAA Fisheries, Pascagoula Lab	adam.pollack@noaa.gov	
Prada	Martha	CORIS	pradamc@gmail.com	x
Rader	Douglas	Environmental Defense Fund	drader@edf.org	x
Rindone	Ryan	Gulf of Mexico Fishery	Ryan.Rindone@gulfcouncil.org	x
Russell	Martin	Australian Government	Martin.Russell@environment.gov.au	
Sadovy	Yvonne	University of Hong Kong	yjsadovy@hku.hk	
Stein	Will	University of New Orleans	wstein@uno.edu	x
Sutton	Glen	Texas Parks and Wildlife	glen.sutton@tpwd.texas.gov	x
Valle-Esquivel	Monica	MRAG Americas, Ltd.	monica.valle@mragamericas.com	x
van Baren	Pieter	Ministry of Economic Affairs,	pieter.vanbaren@rijksdienstcn.com	x

* *Workshop conveners*

Appendix 3. Agenda for GCFI data-limited assessment workshop.

"Evaluation of Current Status and Application of Data-limited Stock Assessment Methods In the Larger Caribbean Region" during 6 November 2013 in Corpus Christi, Texas

8:15 – 8:30 Arrival and coffee
8:30 – 9:00 Welcome and introductions

9:00 – 9:30 Overview of workshop goals, questionnaire responses, and introduce data-limited tools

9:30 – 10:15 Speed presentations – brief overview of different assessment tools (5 min each)

Biomass-based methods:	Ernesto Chavez - Generalized fisheries simulation model (FISMO)
	Claudia Friess - Depletion-corrected average catch model (DCAC)
	Beth Babcock - Density-control ratio rule
Length-based methods :	Josh Nowlis - Size-distribution model
	Mandy Karnauskas - Length-based indicators in Bayesian framework
	Beth Babcock - Uncertainty in length-based estimates of status
Other methods:	Josh Nowlis - Qualitative catch and abundance tool
	Monica Valle - MSC risk-based framework

10:15 – 10:30 Prioritization activity to define small breakout groups

10:30 – 11:00 COFFEE BREAK

11:00 – 12:00 Breakout Group Session 1
Participants will break out into small groups, based on their individual interests in the tools presented. Group members will work together to gain a greater understanding of the assessment methods, as well as discuss the challenges and limitations of the methods. Participants will have the opportunity to analyze their own data, or work with example data sets.

12.00 – 1.15 LUNCH BREAK

1:15 – 1:20 Reconvene for 5 minutes to discuss morning session progress

1.20 – 2.30 Breakout Group Session 2
Participants will have the option of continuing morning group work, or rotating to new groups to familiarize themselves with other tools.

2.30 – 3:00 Workshop participants reconvene to provide break-out group summaries

3:00 – 3:30 COFFEE BREAK

3:30 – 4:00 Interactive future synergies activity
4:00 – 4:20 Wrap-up discussion
4.20 – 4.30 Evaluations

Appendix 4. Pre-workshop survey questionnaire.

Participant Survey for GCFI Data-Limited Stock Assessment Special Workshop

Survey Objective: Collect information pertaining to availability and application of data-limited stock assessment methodologies in the wider Caribbean.
Your name and affiliation: _____

In what capacity are you involved with fisheries management? (Check all that apply)

Fisheries survey design _____ Fisheries data analyst _____
Fisheries data collection _____ Fisheries manager _____
Conservation organization _____ Government _____
Fisher _____ Representative (e.g., buyer, dealer) _____

Do you have access to quantitative tools (e.g., software) that are used for data-limited fishery assessments that you would be able to bring to the GCFI workshop? YES / NO

If YES, please briefly describe these quantitative tools (e.g., software):

Do you have fisheries data that are considered to be data-limited and may serve as a case study for comparing the results from using various analytical tools? Examples include landings data, fishery-independent survey data, monitoring data such as SCUBA surveys, tagging data, or biological data (growth, ageing, maturity, etc.). YES / NO

If YES, please briefly describe the available data sets:

Please briefly describe what you want to achieve by attending this workshop.

Would you be interested in working together inter-sessionally (between annual GCFI conferences) with researchers from another region to assess a data poor fishery? YES / NO

References

Babcock, E. A., & MacCall, A. D. (2011). How useful is the ratio of fish density outside versus inside no-take marine reserves as a metric for fishery management control rules? *Canadian Journal of Fisheries and Aquatic Sciences, 68*, 343-359.

Caribbean Fishery Management Council. (2011). *Exploring tools for managing data-poor stocks CFMC workshop.* San Juan, Puerto Rico: Caribbean Fishery Management Council.

Cope, J. M., & Punt, A. E. (2009). Length-based reference points for data-limited situations: applications and restrictions. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 1*, 169–186.

Daan, N., Gislason, H., Pope, J. G., & Rice, J. C. (2005). Changes in the North Sea fish community: evidence of indirect effects of fishing? *ICES Journal of Marine Science, 62*, 177-188.

Ehrhardt, N. M., & Ault, J. S. (1992). Analysis of two length-based mortality models applied to bounded catch length frequencies. *Transactions of the American Fisheries Society, 121*, 115-122.

Froese, R. (2004). Keep it simple: three indicators to deal with overfishing. *Fish and Fisheries , 5*(1), 86-91.

Gedamke, T., & Hoenig, J. M. (2006). Estimating mortality from mean length data in nonequilibrium situations, with application to the assessment of goosefish. *Transactions of the American Fisheries Society, 135*, 476-487.

Graham, N., Dulvy, N., Jennings, S., & Polunin, N. (2005). Size-spectra as indicators of the effects of fishing on coral reef fish assemblages. *Coral Reefs, 24*, 118-124.

Heyman, W. D., & Adrien, G. (2006). A protocol and database for monitoring transient multi-species reef fish spawning aggregations in the Meso-American Reef. *57th Gulf and Caribbean Fisheries Institute*, (pp. 445-462). St. Petersburg, FL.

Honey, K. T., Moxley, J. H., & Fujita, R. M. (2010). From rags to fishes: data-poor methods for fishery managers. *Managing Data-Poor Fisheries: Case Studies, Models & Solutions, 1*, 159–184.

MacCall, A. (2009). Depletion-corrected average catch: a simple formula for estimating sustainable yields in data-poor situations. *ICES Journal of Marine Science, 66*, 2267–2271.

Martell, S., & Froese, R. (2012). A simple method for estimating MSY from catch and resilience. *Fish and Fisheries, 14*(4), 504–514.

Pilling, G. M., Apostolaki, P., Failler, P., Floros, C., Large, P. A., Morales-Nin, B., et al. (2009). Assessment and Management of Data-Poor Fisheries. In J. C. A. Payne, *Advances in Fisheries Science: 50 years on from Beverton and Holt* (p. Ch. 12). Oxford, UK: Blackwell Publishing Ltd.

Prince, D. P., Dowling, N. A., Davies, C. R., Campbell, R. A., & Kolody, D. S. (2011). A simple cost-effective and scale-less empirical approach to harvest strategies. *ICES Journal of Marine Science, 68*(5), 947-960.

Shin, Y.-J., Rochet, M.-J., Jennings, S., Field, J. G., & Gislason, H. (2005). Using size-based indicators to evaluate the ecosystem effects of fishing. *ICES Journal of Marine Science, 62*, 384-396.

Walmsley, S., Medley, P., & Howard, C. (2005). *Fisheries management decisions with limited resources and data: ParFish Synthesis Document.* London, UK: MRAG Ltd.

Williams, E. H., & Shertzer, K. W. (2005). Effects of fishing on growth traits: a simulation analysis. *Fishery Bulletin, 103*, 392-403.

Wilson, J. R., Prince, J. D., & Lenihan, H. S. (2010). management strategy for sedentary nearshore species that uses marine protected areas as a reference. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 2*, 14-27.