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REPORT OF A GCFI WORKSHOP: BEST PRACTICES AND TRADE-OFFS BETWEEN FISHERY-DEPENDENT AND FISHERY-INDEPENDENT SAMPLING IN DATA-LIMITED REGIONS

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Contents

Executive Summary

The Gulf and Caribbean Fisheries Institute (GCFI) executed a three-year joint initiative, in partnership with the National Marine Fisheries Service (NMFS) that included a series of special sessions and workshops to address the best practices and methods to improve data-limited stock assessments of living marine resources in the Gulf of Mexico and larger Caribbean region. This report provides the results from the third GCFI data-limited assessment workshop held at the 68th annual conference of the Gulf and Caribbean Fisheries Institute (GCFI) in Panama City, Panama during November 9-13, 2015. Additionally, a GCFI special session, entitled "*Strategies for Optimizing Fishery-independent and Fishery-dependent Sampling Collections in Support of Improving Data-limited Stock Assessments in the Wider Caribbean Region*" was held where contributors provided presentations on a diverse set of topics relevant to the theme of the three-year joint initiative.

The terms of reference of this workshop were based on the results from the previous workshops and a pre-workshop questionnaire survey to obtain background information on the level of involvement of the participants in data collection, analysis, and management systems. Participation in the workshop included scientists, managers, and stakeholders from throughout the region, who brought a range of perspectives. Various presentations were given to provide an overview of guiding principles for designing effective monitoring programs in data-limited situations, and to describe case studies of existing fishery-independent and fishery-dependent data collection systems in the regions of Bermuda and the Bahamas. Participants were exposed to presentations and practical exercises on harvest control rules, management strategy evaluation, and general principles of developing management systems. Specific exercises were designed to introduce participants to the use of analytical tools for evaluating the effectiveness of data collection systems, and to provide an opportunity to apply these tools to real case study problems.

During the workshop, participants engaged in breakout group sessions addressing: 1) linkages between data collection and management needs, 2) decision-making criteria that play a role in prioritizing fishery dependent versus fishery independent sampling, 3) stakeholder involvement and improving communication, 4) adaptive sampling approaches, and 5) use of management strategy evaluation (MSE) as a tool to simulate the effectiveness of the data collection and provide a management feedback loop. The MSE breakout group addressed the process of linking resource monitoring, stock assessment evaluations, and harvest control rules that collectively serve as fishery management strategies. The utility of MSE was recognized for providing a mechanism for examining trade-offs between modifying management expectations or harvest control rules to cope with data-limitations versus improving or modifying data collection as a means to promote gains in management performance. Workshop participants collectively identified best practices and recommendations for improving data collection programs and stock assessments in data-limited situations, including the utility of MSE as a platform for management transparency, consensus building, and for illustrating expected control rule performance prior to implementation.

Background

This workshop, hosted by the Gulf and Caribbean Fisheries Institute (GCFI), was the third of a series of workshops proposed to help strengthen scientific capacity in the Gulf of Mexico and wider Caribbean region. The work group identified best practices and strategies to improve data collection and management of data-deficient stock assessment methods, and to better engage stakeholders in the process. 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.

In the Gulf of Mexico and Caribbean regions, stock assessment evaluations are challenged by the size and diversity of the resource area, costs of conducting surveys relative to value of the fishery, complexities in life history patterns of marine organisms, and difficulties in sampling habitats that are inaccessible to conventional sampling gear such as trawls and traps. The difficulties of managing these subtropical marine resources are further complicated by the environmental effects on the marine ecosystem, diversity of fisheries and geopolitical challenges across jurisdictional boundaries. Fisheries stock assessments in the region are commonly characterized as "data poor" because they lack sufficient data with which to determine stock status and reliably provide management advice.

The overarching theme for the GCFI data-limited workshop series 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. This strategy operates through a series of workshops that bring together experts to address key requirements to improve data-limited stock assessments in the region. The 2013 special workshop, convened in Corpus Christi, Texas, focused on identification and characterization of the requirements of the modeling methods commonly used in the region (Cummings *et al.* 2014). In furthering this capacity building strategy, the 2014 workshop set about to develop a plan for improving fishery-dependent data collection systems (Cummings *et al.* 2015). In this report, the third workshop emphasizes the best practices and tradeoffs in optimizing fishery independent versus fishery dependent sampling. Overall, the three workshop reports collectively emphasize the key concepts and challenges of collecting and analyzing the scientific information appropriate to meet management needs in data-limited regions.

Welcome and Introduction

The conveners thanked the presenters for contributions to the GCFI special session in *Appendix 1*, and welcomed the participants *(Appendix 2)* to the third GCFI data-limited stock assessment workshop. It was noted that the attendees represented a diverse group of fishery biologists, natural resource managers, academic professionals, fishers, and non-governmental organizations from various countries throughout the Caribbean region. This multidisciplinary effort is considered paramount to enhancing the success of fishery improvement projects and particularly those

rected at optimizing data collections, the latter of which is a priority for conducting reliable stock assessments. The workshop agenda was reviewed *(Appendix 3)* and unanimously approved by the participants.

Overview and Goals

This workshop was the third in a series of GCFI special workshops that progressed sequentially to provide recommendations for building scientific capacity to achieve sustainable marine fishery resources and healthy and productive marine ecosystems in the Gulf of Mexico and wider Caribbean region. This includes the fundamental requirements of improving fishery data collection programs, identifying relevant statistical analysis tools, and providing technical capacity in the use of appropriate analytical tools.

The ability to conduct stock assessments, particularly in the Caribbean region, is often limited by insufficient data regarding catch history, length frequency distributions, and patterns of growth and reproduction. A high degree of uncertainty in stock assessments often results from inadequate capacity to collect scientific data or to monitor landings of the different fleets in an area. Regardless of these data deficiencies, managers must still make policy decisions to maintain the sustainability of the harvested marine resources. This workshop provided the opportunity to identify and evaluate the methods and data collection systems in use in the region, to identify strategies for optimizing statistical systems taking into account technological advances and existing challenges, to identify solutions for engaging stakeholders early in the data collection process, and to recommend the best practices in data collections for minimizing uncertainties in data-limited stock assessments.

Workshop conveners provided a brief overview of the workshop goals and expected products. Building upon the findings from the previous 2013 and 2014 workshops, the objectives of this workshop were to: 1) review combined data collection and management systems in the region, 2) determine minimum data requirements for data poor stock assessment methods, 3) recommend strategies for optimizing fishery dependent and fishery independent data collection, and 4) align data collection to management goals using analytical tools such as management strategy evaluation (MSE). A secondary objective was to identify and apply novel strategies that enhance stakeholder engagement in the design of data collection systems. Building consensus among scientists, managers, and stakeholders is a key component to improving stock assessments in the region, particularly in data-limited and resource limited environments. Participants of the workshop series

were asked to consider themselves as a study group who will continue to work on this effort beyond the workshops, and help guide the direction of subsequent activities that will address fisheries-dependent and fisheries-independent data requirements.

Participants agreed on the following workshop goals:

- Review factors impacting the decision process in determination of resource allocation between fishery-independent and fishery-dependent sampling (e.g. fishery economic value, management tool, priority, stock assessment method of choice, as identified in objective 1),
- Identify primary sources of uncertainty affecting allocation of sampling funds/resources between fishery-dependent/independent sampling (e.g., through review of fishery sampling systems as identified in objectives 1 and 2) ,
- Evaluate the trade-offs for a variety of case studies with high, moderate, and low resources available for implementing fishery-independent versus fishery-dependent data sampling programs, taking into consideration important factors impacting sampling (identified in objectives 2 and 3),
- Review and examine analytical tools to formulate decisions in optimizing fishery-dependent and fishery-independent sampling programs (e.g., through MSE as identified in objective 4)

Pre-workshop Questionnaire

Prior to the 2015 GCFI workshop, a questionnaire *(Appendix 4)* was distributed to query participants on the ongoing developments and challenges relevant to data-limited stock assessments within the larger Caribbean region. Responses to the questions were used to develop the framework of the workshop.

To familiarize participants with the backgrounds of the various participants, a summary of the pre-session questionnaire

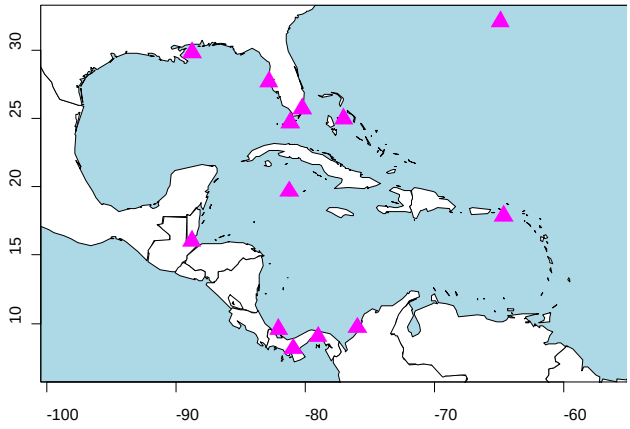

Figure 1. Home locations of workshop participants as identified by the questionnaire.

responses was presented. Survey respondents originated from a wide range of locations throughout the region (Fig. 1). Although the survey provided perspectives from scientists, managers, and stakeholders, the majority of the questionnaire responses were from individuals with experience in data collection, survey design, or data analysis (Fig. 2). The majority of participants (70%) were familiar with the concept of MSE, but only a single participant had actually carried out an MSE in practice.

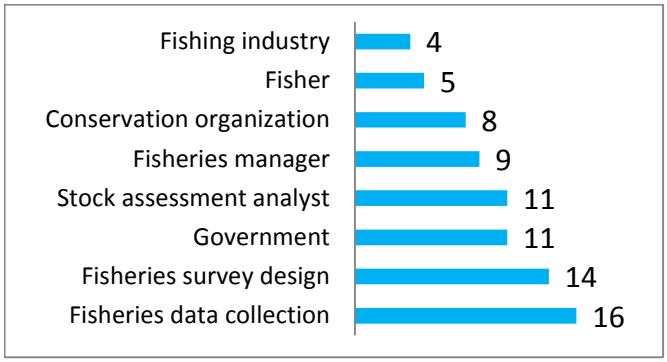

Figure 2. In what capacity are you involved with fisheries management?

Participants were asked to identify the major factors impacting decisions relating to the apportioning of fisheries sampling in their respective regions. Funding and political pressures were identified as the most influential factors, with assessment and management goals and statistical considerations being of lesser importance (Fig. 3). Stakeholders were thought to be involved in decision-making processes relating to sampling in half the regions surveyed (Fig. 4).

Terms of Reference

Upon review of the pre-workshop questionnaire results and goals of the workshop, the workshop participants unanimously agreed on the following terms of reference.

1. Identify factors and limitations influencing the optimization of data collections between fishery-independent and fishery-dependent sampling,
2. Explore use of analytical tools to evaluate the impacts of sampling decisions on stock assessment outputs and management advice, and
3. Discuss mechanisms for enhancing stakeholder input in the decision-making process for both fishery-independent and fishery-dependent sampling design.

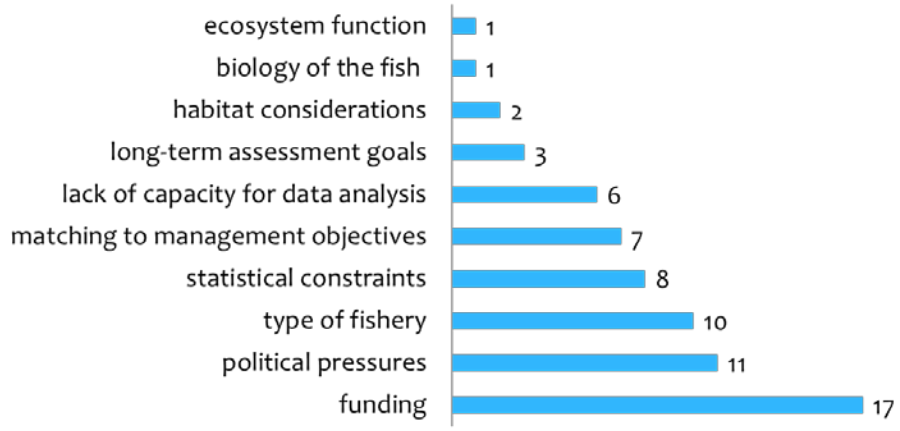

Figure 3. What are the major factors impacting the decisions relating to apportioning of fisheries sampling in your region?

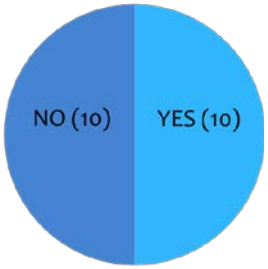

Figure 4. Are stakeholders currently involved with the decision-making processes related to sampling programs in your region?

Keynote Address: Guiding Principles for Development of Effective Monitoring Programs

Bob Trumble gave a keynote address to the workshop participants providing background linking management goals to assessment methods to decision-making regarding sampling. This background provided the framework for the workshop discussions relevant to case studies describing the real world environment of fisheries managers, identification of concerns and the environmental problems manager face, and considerations of components affecting costs. An aim put forth was to have participants working jointly to identify solutions and good practices that play a major role in decision-making, and to balance multiple objectives in optimizing between fishery-dependent and fishery-independent sampling.

Trumble noted that fisheries managers frequently struggle with multiple constraints in designing sampling systems, including: costs, spatiotemporal coverage issues, and logistical constraints (e.g., diverse fisheries to cover). These issues must be considered in the context of decision-making. Initial considerations in establishing a sampling plan should consider the identification of what needs to be monitored and why, and what enforcement considerations are to be considered from a practical and logistical perspective. In addition, identification of the level of resources and who (government, industry) will conduct the monitoring program will be dependent on the prioritization of components to be addressed. These issues are critical to the success of monitoring programs. Successful sampling programs will by necessity identify relevant monitoring strategies with considerations to 1) at-sea fishery-dependent versus dockside, 2) fishery-independent versus fishery-dependent and relevant gains in accuracy, 3) tradeoffs in data collection through self-reported systems versus observer, 4) logistical sampling considerations (electronic monitoring and logbook) including validation systems, spatial and temporal coverage versus quality and value of data. At the onset of design, attention should be given to overarching goals of the program with attention to 1) stakeholder involvement, 2) competing goals between user groups (fishers), managers, enforcement, and 3) recognition that prioritization and adaptive strategies should consider the value of information and strengthen its timeliness, credibility and transparency.

Regional Case Study 1 – Bermuda

Joanna Pitt (Government of Bermuda Fisheries Department) gave a presentation on the fishery-independent and -dependent monitoring activities in Bermuda. Bermuda is a small isolated oceanic island with approximately 991 km^2 of mainly shallow reefs. Joanna's presentation focused on the current regulatory framework in place to monitor and control harvest. A licensing system is in place for commercial fishers; licenses are required to sell catch and fishers who sell must submit data on harvest. Commercial harvest records date back to 1975. Since 1984, the commercial fishery has operated under a limited entry system with a cap of 200 licenses presently. Recreational fishers cannot sell catch. Joanna noted that licensing is also needed for recreational fishing and particularly for spearfishing and lobstering activities. Bermuda enacted a ban prohibiting fish pots

in 1990. Subsequently, line fishing activities (rod and reel, troll) expanded soon after in the offshore pelagic zone. Specific license provisions exist for lobster traps. In addition to input controls (e.g., limited entry, gear type, gear prohibitions), spatial management (seasonal) and area closures such as marine protected areas (MPAs) are used to control harvest. Output controls include daily bag limits and minimum size restrictions.

Joanna also discussed the current monitoring constraints for the Bermuda fisheries that are factored in the decision-making process relating to fishery-dependent versus fishery-independent sampling. Constraints noted included: dispersed landing sites, private docks, existence of multispecies fisheries with many species landed in low numbers, absence of central markets, and lack of organized processing. In addition, limited industry cohesion (no cooperatives or organized representation) and recent (since 2002) reduced governmental resources available for fisheries management and research contribute to the monitoring constraints.

Joanna profiled five important Bermuda fisheries (parrotfish, mussel diver, spiny lobster, sharks, and black grouper) noting specific characteristics within each fishery for which various decisions were made regarding the optimization of sampling:

Parrotfish fishery:

In 1990, a ban in the use fish pots was implemented when the landings of species such as herbivores, including parrotfish, declined. Initially commercial fishermen were uncooperative with this controversial ban. More recently, through policy changes and improved political will, public support has improved. Although recognition of conservation needs has strengthened, there exists a need to evaluate and provide scientific basis for what is still an unpopular management measure. In response to lack of harvest information resulting from the ban, a need for a fishery independent measure of abundance developed; thus the implementation of a visual census survey in 1990. This survey provides information on resource status across a suite of habitats thus filling a void in data previously available from the directed fishery. Scientific information collected through the visual census survey enables the evaluation of performance of the current management strategy.

Turkeywing Mussel Diver fishery:

In 1994, dredging for mussels was banned due to concern of habitat degradation. Changes to this fishery's regulations included a provision allowing harvest by single divers while free-diving in a "closed reservoir" under limited entry. This relatively new fishery, operating under limited entry and in a closed area, allowed for easier access for fishery-independent monitoring. In addition, incorporation of spatial distribution information is deemed critical for maximizing efficacy in sampling and for minimizing bias in results.

Spiny Lobster fishery:

This fishery has a history of strong management composed of a mixture of input controls (limited entry and gear restrictions standardized trap design), output controls (size limits), spatial and closed seasons (spawning areas) in place. Fishery-dependent monitoring is critical for this fishery in part due to the level of market-driven landings influenced partly by tourism, thus an intensive fishery-dependent sampling program exists. As the fishery operates under limited entry and is relatively small (n=29 fishers), sampling provides for monthly catch-per-unit-effort (CPUE), effort, composition (size) data, and discards of undersized lobster (self-reported). Concerns

relating to this current monitoring system include: underestimation of effort (lost traps), bias due to self-reporting, and lack of catch validation. Regulations require standard gear (fish traps), thus catchability can be assumed to be relatively constant.

Shark fishery:

The society of Bermuda recognizes the importance of monitoring of shark populations based on their ecological and socioeconomic importance, and their concerns about global and local declines in shark populations. Changes in traditional behaviors (e.g., a decline in practices to target shark pups) have been observed, while some practices continued to be maintained (targeting large sharks for use as lobster bait).

The relatively small size of the fishery provides an opportunity for multiple sampling methods for monitoring purposes: a social survey, combined with fishery-dependent monitoring which provides input for monitoring and evaluating status. Issues affecting quality of information obtained from directed fishers include misidentification of species and bias of self-reported data. Positive factors contributing to this design include: size of fishery, strong political will leading to strong participation by the fishers, and engaging with academic researchers for sampling.

Black Grouper fishery:

This fishery is considered very important in Bermuda to multiple user groups: commercial fishers (spear fishers, divers), restaurants, and recreational fishers. The species is long-lived with late maturation, characterized as a protogynous hermaphrodite, known to form aggregations to spawn, and is vulnerable to over-exploitation due to life history characteristics. In addition, the usage of deep trolling gear leads to disproportional targeting of females.

The drive for monitoring includes importance to local economy and need for precautionary management due to vulnerability. There is general consensus that age, growth, and reproduction data are adequate and reliable for monitoring. Catch and release experiments are not practical for data collection due to barotrauma. In addition, data on spawning aggregations exist. Regulations also are in place for recreational harvest including areas closured to reduced harvesting during the seven-month spawning season, and reduced possession bag limits (1/vessel) and a size limit (>95 cm FL). Poor bag limit compliance is thought to be an issue as this species is very valuable. These issues complicate the efficiency of any fishery-dependent monitoring.

Regional Case Study 2 – Bahamas

Lester Gittens (Bahamas Department of Marine Resources) presented a case study on the management of Bahamas spiny lobster. He began by highlighting the large spatial scale of the fishery and the economic importance of the country's lobster exports. Lester described the existing fisheries catch statistics and information available on surveys and recruitment. The inputs and results of the 2012 stock assessment were also presented. Lester briefly explained a harvest control rule and stock size reference point that were developed in collaboration with stakeholders to regulate and maintain a sustainable fishery. He concluded by highlighting the absence of local recruitment information and by reflecting on the costs of resolving data deficiencies.

The Bahamas lobster fishery involves over 9,000 fishers across a vast area of 116,000 km^2 with numerous fishing grounds, thereby requiring significant resources to monitor. The Bahamas lobster fishery is export-oriented with the majority of landings passing through processing plants. Reporting of landings is only required if the lobster are to be exported, and fishing licenses are not required for vessels that are less than 20 feet. There is an unknown amount of illegal unreported and unregulated (IUU) fishing. Since external inputs to the Bahamas lobster population are believed to be minimal, local management actions are believed to affect future local abundance.

Fishery data for the Bahamas lobster fishery consist of landings collected since 1982, catch per unit effort (CPUE) since 2007, size frequency, and economic data. Landings data are obtained from officers conducting interviews from volunteer fishers and from purchase reports that are mandatory for exports. CPUE data are collected through officer conducted interviews and from a catch certification system that started in 2010. CPUE data are considered more reliable since 2010 after the catch certificate program began. The size-frequency data were available from small scale sampling at processing plants where sampling has varied spatially and over time. The economic data includes fisher sales prices and export prices. There are no data related to IUU fishing. Other data gaps include: lack of catch information from small vessels (< 20') that are not required to be licensed, foreign fisheries recreational harvest, and direct sales to restaurants. There are no fishery-independent estimates of abundance. Lastly, although both growth and recruitment are known to be seasonally and spatially variable, there are no local fishery-independent estimates of recruitment.

In 2012, a stock assessment for lobster was completed using data through 2010. All spiny lobsters in the Bahamas were modeled as a single stock. The inputs for the assessment were landings by month (tail weight), CPUE by gear (trap and scuba), and recruitment from Florida and from Turks and Caicos. The results of the assessment suggested that the stock was above the trigger reference point of 40% SSB. Although encouraging, the results were also notably sensitive to recruitment. Recruitment from the Turks and Caicos contributed to a substantially healthier stock status in comparison to the Florida recruitment. An external review of the assessment deemed that the assessment approach was appropriate for use in evaluating management options. The reviewers suggested using Florida's recruitment to err on the side of caution.

To maintain a healthy stock and a sustainable fishery, a set of control rules were developed with stakeholder input. The current harvest control rule sets a target export quota of 7 million lbs and specifies conditions that trigger additional restrictions. An annual CPUE that is 50 lbs per person or lower triggers a reduction in the quota. An annual CPUE that is 40 lbs per person or lower triggers a fishery closure. Reviewers suggested a more conservative quota of 5 million lbs to account for IUU, but stakeholders preferred the larger quota with more conservative conditions for triggering quota reductions.

Currently, the management of spiny lobster in the Bahamas relies on the assumption that recruitment in Florida is representative of recruitment in the Bahamas. Substantial efforts would be needed to obtain local recruitment data and justifying costs of collecting the data is complex. Since lobsters have a long larval duration period, there may not be strong links between larval recruitment and adult population. Furthermore, recruitment may vary spatially throughout the region. The costs of collecting the data must be justified, balancing the likelihood that the data will be informative for assessment, particularly since a number of years of data are necessary prior to use in future assessments. The likelihood that the data will be informative depends on a relationship

existing between local larvae or semi-adults and future local adult population, and on collecting data at appropriate spatial scales to adequately quantify the relationship. Gaps in data (e.g., recruitment, fishery independent abundance indices) add uncertainty in evaluating the Bahamas lobster stock. The costs of improvements in data collection will need to be offset by benefits of reducing uncertainty.

Surplus Production Model Excel Interactive Demonstration

Adyan Rios (NOAA Fisheries) presented an interactive teaching tool that was developed to quickly and comprehensively introduce fundamental topics in population dynamics and fishery management. It consisted of a short presentation and a two-part spreadsheet exercise. Prior to the exercise, Adyan provided a short introduction to concepts including the following: populations, density dependence, surplus production, maximum sustainable yield, overfished, overfishing, surplus production models, uncertainty and bias. The presentation addressed the key principles of a sustainable fishery, balancing removals with stock production. The first part of the exercise was to examine a simulated surplus production curve and related stock status over time under various condition addressing economic and biological considerations. The second part of the exercise was to explore implications of introducing bias and uncertainty in the simulated fishery data and the resulting effects on estimates of stock sustainability.

The spreadsheet exercise was based on a surplus production model fit to a simulated fishery. The exercise was designed to facilitate user interactions by including tables and graphics that change according to in user inputs. In the first part of the exercise, individuals were encouraged to change input values and understand the components of modeling a simulated population. The following trigger questions were used to guide modifications to model inputs and help users interpret changes under various conditions:

- How can the user change the simulated model inputs to maximize the population size?
- How does the population change over time when annual catch exceeds annual production?
- How does the catch landed over time change when annual catch exceeds annual production?
- How does altering carrying capacity change the stock production curve? What factors limit carrying capacity in real populations?
- How does the intrinsic rate of population growth affect the speed at which a population reaches the carrying capacity? What are some example species that would have high intrinsic growth rates?

The second part of the exercise involved exploring uncertainty in data. Building on the model that was explored in part one, individuals could now compare the effects of introducing variability (noise) and bias into the simulated catch and effort data. The following trigger questions were used

to guide how users explored and understood the implication of directional bias and increasing variability:

- What happens to estimates of stock status when landings are underreported?
- How does noise affect estimates of overfished and overfishing compared to true states?
- What are sources of uncertainty and bias in real fishery data?

Management Strategy Evaluation

Bill Harford (University of Miami) presented a fishery system as an interconnected set of processes, including:

- Population dynamics of the target organism(s)
- Sampling
- Analysis
- Harvest control rules
- Implementation

All of the component parts are analyzed collectively and outcomes are presented in terms of whether they lead to achievement of fishery management objectives. He described *Management Strategy Evaluation* (MSE) as a tool that can be used for simulating system feedback. This means that recursive decision-making responds to changes in the state of the fishery that arise from previous decisions, and various other ecological and environmental effects. Since components of the fishery system influence each other, MSE is useful in designing data collection procedures because performance is measured in currencies related to achievement of management objectives.

Bill summarized a seven-step MSE framework presented by Punt (2016):

1. Identify objectives – The identification of management objectives is necessary for MSE. The objectives of management may dictate the sampling (data collection), analysis (assessment), and harvest control rule. Objectives are translated into performance measures.
2. Identify uncertainties – Key uncertainties are represented as alternative model configurations, which allows management strategy performance to be calculated across a range of conditions.
3. Develop several operating models – Alternative model configurations reflect a variety of considerations, including key ecological uncertainties.
4. Specify methods for quantifying parameters – Generally this is done via a formal assessment or formal stock assessment or other data analysis.
5. Identify candidate management strategies – These consist of the instructions for data collection, analysis, and catch regulation via a harvest control rule.
6. Simulate the application of each management strategy.
7. Evaluate results and modify as needed – Evaluate whether a given management strategy led to achievement of the stated objectives, through examination of performance measures.

Harvest Control Rule Overview

Nancie Cummings (NOAA Fisheries) gave a review of harvest control rules (HCRs) including brief background on development of HCRs in the United States, the use of HCRs in management, key factors to consider in design of HCRs, and examples of HCRs in data-limited environments. Generally speaking, HCRs are intended to apply broadly and to be robust to perceived sources of uncertainty. HCRs need to be transparent and should be based on the best science information available. The ability to test and evaluate (e.g., via simulation) HCRs is important in fisheries management, and enables the capability to facilitate changes in management when necessary. This allows for establishment of catch thresholds to facilitate effort control (e.g., setting of Overfishing Fishing Limit (OFL), Allowable Biological Catch (ABC), Annual Catch Limit (ACL), thereby providing for buffers to incorporate management and scientific uncertainty. HCRs should also incorporate feedback from stakeholders, especially in their development. A chief desire is that buffers should be as small as possible, while keeping risk of overfishing low. Also important are accountability measures (AMs) that act as management triggers which occur at predetermined thresholds, and may include such measures as seasonal closures or changes in trip or bag limits.

Nancie then detailed the Harvest Strategy Policy (HSP) for Australian fisheries as a case study. Important characteristics for this HSP include: 1) a partnership approach between fishers, scientists, managers, and Non-Governmental Organizations (NGOs), 2) strategies for large fisheries that incorporate spatial, temporal, direct and indirect effort controls, 3) employing a tiered approach used for data-poor and/or low-value fisheries, with data quantity and quality determining the tier used for the data-poor and/or low-value fisheries. This HSP is built around target benchmarks (Btarget, Blimit) that act as management triggers. Such triggers require inputs from a stock assessment model or are scientifically defensible proxies used in the absence of real data. Nancie concluded the presentation with Australian fishery HSP examples: the southern and eastern scale fish and shark fishery are considered a data-moderate fishery and the western deep-water trawl fishery is considered to be low-value fishery characterized by less information on the fish population. Of key significance in the Australian HSP goals are the specific objectives that work

to improve the status of the fishery and thus the ability to develop more informative harvest strategies including: use of trigger levels as reference point proxies, identifying data-gathering protocols and subsequent simple analyses to better assess the fishery, archiving biological data for possible future analysis, and spatial management. However, there is recognition that there are tradeoffs between the information gained and possible increases in harvest and monitoring costs.

Breakout Group Discussions

After the initial presentations (Keynote, case studies, MSE and HCR overview), workshop participants divided into groups to discuss and consider the morning's topics in more detail. Four groups were identified according to the primary interests of the participants: 1) Management strategy evaluation, 2) harvest control rules, and 3) interactive Excel tool. These groups were each given specific tasks: 1) apply the MSE technique to a specific region and fishery, 2) design a harvest control rule for a specific region and fishery, and 3) further consider the utility of the Surplus Production Model Excel tool in an educational environment. The primary discussions emerging from these breakout sessions are detailed below.

Management Strategy Evaluation

The MSE breakout group addressed the process of linking resource monitoring, stock assessment evaluations, and harvest control rules that collectively serve as fishery management strategies. Linking each part of a management strategy helps to define a management strategy as an interconnected process. By simulating the complete management process using MSE, the breakout group was able to measure the collective performance of an entire management strategy in terms of whether management objectives were expected to be achieved.

Two data-limited MSEs were examined in detail by workshop participants, leading to several lessons learned about data collection and its effective use in decision-making. In the first MSE example, the break-out group addressed decision-making in the face of a severe circumstance

involving only reliable catch data being available to guide management decisions. In this case, the MSE revealed where breakdowns were likely to occur in the management process; discussion centered on the trade-offs associated with avoiding such breakdowns through improved data collection or through re-formulation of harvest control rules to avoid the circumstances that led to poor management outcomes. In the second MSE example, the breakout group addressed whether an additional data stream could improve stakeholder economic opportunities relative to the status quo for a spiny lobster fishery with hypothetical characteristics similar to those in the Bahamas.

Upon engaging participants in the design of the management strategy, an issue emerged in that a proposed harvest control rule (and not the additional data stream) could inadvertently reduce fisher opportunities. This discussion exemplified the value of MSE in bringing transparency to policy development, revealing a harvest control rule that seemed appealing in concept but that did not achieve priority management objectives.

By simulating expected management outcomes, participants gained an awareness of the interconnections between monitoring, assessment, and decision-making, which led to the identification of several good practices. Participants identified the utility of MSE for examining how design of data collection and monitoring practices influence the overall achievement of management objectives. Related to data-collection in data-limited circumstances, participants identified the utility of MSE for examining trade-offs between modifying management expectations or harvest control rules to cope with data-limitations versus improving or modifying data collection as a means to promote gains in management performance. Finally, participants recognized the utility of MSE as a platform for management transparency, consensus building, and for illustrating expected control rule performance prior to implementation.

Harvest Control Rule Breakout Group Discussion

Participants taking part in this breakout group were asked to work together to design a harvest control rule (HCR) for a specific fishery and region, and to consider the following as guidelines in the activity:

- Identification of a Management Procedure (MP) and rules,
- Knowledge of current status of stock and uncertainty,
- Cost to improve status (data collection),
- Determination of acceptable buffer and acceptable risk level and estimated cost to lower the risk,
- Potential ecosystem considerations (multi-species concerns, uncertainty),
- Implementation strategy and costs, and enforcement and governance concerns.

Other suggested considerations included: biological and ecological, management approaches, scientific knowledge, monitoring capacity, overlap in management jurisdiction, resource users, discards, and effects on endangered/threatened species (ETP). Through incorporation of these management constraints and goals, data sufficiency and quality, and enforcement participants were encouraged to follow the earlier overview on best practices for HCR design. This also included

incorporation of constraints from a biological perspective of the organism targeted by the fishery and the availability of data and enforcement.

A major concern noted by this group was the need to balance the unique management objectives in each of the case study fisheries for which they were familiar and wanted to address. The group noted the control rules would need to be responsive and supported by the stakeholders. The discussions were focused on three fisheries that exemplify some of the challenges in determining HCR for different fisheries.

The first fishery discussed was the nearshore coastal speckled seatrout fishery in Mississippi that is targeted primarily by the recreational sector. This is a diverse sector comprising fishers that target the stock for sport with the desire to catch trophy sized fish, and other fishers primarily interested in catching fish for subsistence. The challenge for managers is to determine a harvest control rule that is applicable to both sectors. The group discussed how slot and bag limits had different impacts on these user groups. Harvest control rules are determined using MSY, yet the breakout group raised the question of what types of alternative HCRs could be used.

The second fishery discussed was the queen conch fishery in Puerto Rico. This stock is exploited by the recreational and commercial sectors. Underreporting is a major problem in this fishery resulting in the lack of a reliable measure of CPUE. This problem precludes confidence in stock status. Selection of a suitable measure of effort has also precluded a definitive stock status estimate, and additionally there has been little to no enforcement of the minimum size limits currently in place. The “de facto” size limit is enforced in the commercial sector because small conch are not a “worthwhile” target. The wide geographic distribution of effort makes the monitoring of this fishery especially difficult, thus the development of any useful HCR to sustain a healthy resource has proven problematic.

The third fishery discussed was the snapper/grouper fishery in the Gulf of Mexico. This fishery is highly valued by both the commercial and recreational sectors. The two sectors diverge in their interests, thus the harvest control rules discussed by the breakout group reflected the differences of these two sectors. Ideally, the HCRs would be applied to a sector-based allocation scheme as they would need to be modified if they were applied to the unallocated fishery. Recreational anglers have been under severe restrictions for many fish, such as red snapper, and the ideal HCR would be based, similar to spotted seatrout, on “increased opportunity” to target a species. Bag limits or the ability to harvest co-occurring species might be a sub-HCR that could be used to increase opportunity. Commercial angler’s motivations are different from recreational. Commercial anglers want to optimize opportunity to target species of marketable size over a long

period, but also want to maximize the return on investment. An appropriate HCR could be 'if the average size of target decreases by X, therefore, the ACL could be reduced to return the species population to an appropriate size.'

Surplus Production Model Tool Breakout Group Discussion

A breakout group discussed the educational purpose and benefits associated with the Surplus Production Model Tool. The group also recommended ways to enhance utility and add complexity in future versions.

In addition to education and outreach, the use of the tool was recommended as an icebreaker activity to introduce common terminology (e.g. MSY, overfished, overfishing, and sustainable) and as a warm-up activity to demonstrate fundamental principles of population models before moving to models with higher complexity. Suggested goals associated with using the tool included:

- Interactively teach concepts including surplus production, uncertainty and bias,
- Strengthen understanding of fundamental relationships used in stock assessments,
- Show that uncertainty in data results in misinformation, and
- Convey that models and simulations are useful for evaluating management options.

Several advantages of the tool's current design were noted. For example, the accessible platform and practical visual representations provide transparency of inputs and computations. The interactive approach and the sequential introduction of complexity facilitate learning new topics quickly and comprehensively. Lastly, the optional levels of complexity allow customizing exercises to target specific goals or audiences (*e.g.* students, stakeholders, council and advisory panel members, diverse forums).

Suggestions for enhancing utility of the tool were discussed by the breakout group, and included:

- Customize presentation and trigger questions for specific audiences,
- Focus presentation on concepts (not formulas) and consistent international terminology,
- Simplify plots and use identical visuals in spreadsheets and in presentations,
- Adapt the exercise to extend understanding of management benchmarks and future yield projections,
- Adapt the currently deterministic exercise to better convey randomness,
- Increase flexibility in how users can manipulate uncertainty, and
- Weigh accessibility benefits of using a web application of the tool vs Excel based application (Excel provides more transparency but can be more prone to user error).

Additional complexity could be incorporated into future versions of the tool. The group identified bootstrapping, recruitment variability, changes in fishing power, and tradeoffs between precision and data requirements as topics of additional complexity to individually consider. Moreover, the information from the tool could be carried over into an MSE extension to further demonstrate how models and simulations are used in fisheries management.

Closing Remarks - Day 1

The first day of the workshop ended with brief summary remarks by the conveners. Each participant was then asked to identify one topic they would like to revisit on Day 2 or to suggest alternative topics. Suggested priority topics to discuss in more detail included: electronic monitoring and applications, survey design/analysis improvement, regional monitoring schemes, incentives for increasing fisher participation in logbooks and data collection technologies, data requirements per species group/management objective, and better quantification of catch. Some participants also were interested in additional examples of harvest control rules, good practices for incorporation of anecdotal information, and exploring MSE results in simulations of greater complexity. The conveners also asked the participants to further consider each of their own local management environments in terms of identifying at-home data collection problems or concerns to further address on Day 2. Participants were reminded to consider current management objectives and the specific challenges they faced in collecting adequate data to quantify stock status.

Reflections: 2013-2014 Workshops and Future Directions – Day 2

The second day of the workshop was opened with a brief summary of the activities and accomplishments of the previous day. Nancie Cummings reviewed the original impetus of the workshop series and the progression of foci over the three years. She noted that the activity was funded by NOAA, with the recognition that the connectivity of fishery stocks extends beyond U.S. jurisdictions, and thus effective management required international collaboration. The first workshop, held in 2013, focused on a review of some of the data-limited assessment tools that were available at that time. There is recognition that new tools have been developed and operationalized since then. Action items from that first workshop were to continue collaborations and pursue simulation approaches to testing data-limited approaches, which has led into some of the activities presented at the current workshop. The 2014 workshop was focused on fishery-dependent data collection, matching data collection to management needs, and the continuing need to involve stakeholders in data collection. The workshop was initiated with a series of talks on classical sampling design, and then moved to explore case studies from the region. This year's workshop is subsequently focused on the optimization of combined fishery-independent and fishery-dependent data collections systems. The goal is to converge on best practices that can be used to guide decision-making in participants' home countries. Nancie noted that the results of the 2015 workshop were to be presented at the general GCFI plenary session on Thursday morning.

Bob Glazer, Executive Director of GCFI, then made brief comments on how the activities and results from this data-limited workshop series play into the larger goals of the GCFI. He noted that while this was the last workshop in the three-year series, the work was important to GCFI and will be instrumental in developing its future strategic initiatives and partnerships. This is aligned with the GCFI's strategy to promote educational initiatives for upcoming fishery professional and learning opportunities to engage stakeholders. From a strategic perspective, GCFI provides an international forum to develop partnerships among scientists, managers, and stakeholders having a common goal of improving scientific capacity based on best practices for the sustainability of marine resources in the Gulf of Mexico and larger Caribbean region. Bob noted that NOAA has recently awarded a five-year grant known as the "Ocean Innovation Strategic Initiative." Within

this grant, there are opportunities to build upon what has been done in this series of data-limited workshops, but also to address other challenging fishery problems in the region.

Review of Data-limited Methods since 2013 Workshop

Mandy Karnauskas (NOAA Fisheries) gave a presentation to review progress on data-limited assessment methods since the 2013 workshop. The purpose of the presentation was not to provide a comprehensive review, but rather to recognize the need to bring data collection issues full circle to the intended use of the data. As such, the presentation was intended to provide a brief update on some of the tools that had been developed as well as several comprehensive publications that had recently been released, and also to provide cautionary notes and highlight potential pitfalls in selecting an assessment process.

Mandy noted that the term "data-limited" can have different meanings in different contexts, sometimes even being equivalent to "data-absent." Data-limited tools can range from qualitative to quantitative, and can yield different types of outputs. Mandy clarified the term "management procedure" which can be used in a variety of inconsistent contexts. The ultimate goal of a management procedure is to develop a management action which can often be to manage the stock toward some optimal yield estimate, but could also be to move the stock in a favorable direction; for example, toward the level that would produce a desirable CPUE agreed upon by stakeholders. A hierarchical table was presented outlining the range of methods, from data-rich to data-poor, and from quantitative methods to semi-quantitative to stock assessment support tools (*e.g.,* risk assessment approaches).

It was noted that there is generally a tradeoff between the amount of data and the number of assumptions – in data-poor methods, greater assumptions about the stock structure or underlying driving processes must be made. The danger in using data-poor methods however lies not in the assumptions themselves (as all models make assumptions), but in that the assumptions may be less explicit in the data-poor realm. Thus, advice is that before approaching any data-limited tool, one must dig in and carefully understand assumptions associated with the approach, before deciding whether or not these are consistent with the scenario at hand. Data-rich methods are not by any means robust to incorrect assumptions, but they differ in that the assumptions are often more clearly stated, and the violation of assumptions may more easily be detected through model diagnostic outputs; for example, in finding contradictory model fits to different data streams. Also, processes such as wholesale regime shifts, habitat changes, or altered levels of stock productivity would be very difficult to detect in most of the data-limited approaches.

One approach to address uncertainty in assumptions is to project uncertainty in model inputs through the assessment process. For example, for depletion-based methods the assumed level of depletion is often not well known, so the analyst can test a range of inputs and understand how this uncertainty affects the result. However, such a process cannot be used to understand the implications of structural uncertainty, *i.e.,* incorrect assumptions about the dynamics being modeled. A comparison was made to hurricane modelers, who are able to test how well their physical predictions performed by comparing to the known track of the storm. Unfortunately, in the fisheries realm, we never can fully observe the known "track" of the fish population, and thus the only way to test model performance is through simulation – specifically management strategy evaluation. The importance of this analytical tool was thus emphasized through this comparison.

The presentation concluded with a review of recent data-limited literature that had come out since the 2013 workshop, and a discussion of some of the major take-home messages from these works. It was noted that these could provide a very useful starting point for a manager just starting out with developing a management process.

Case Study: Use of Anecdotal Information to Guide Sampling

Bob Glazer gave a presentation on adaptive sampling, based on a case study for conch in Florida Keys. The management objective was to estimate the spawning biomass of conch, and the method used is a probabilistic approach that divides the sampling area into zones based on rough probability of encountering a conch. The survey is adaptive in that it adjusts the probability definition of the zones as new information comes each year; ultimately, as information is perfected, the zones converge toward an equilibrium definition. To initialize the areas, the investigators used gross areas of habitat (inshore/offshore, bathymetry), as well as previous information on 30 high-density spawning aggregations that had been historically monitored; however, none of the existing habitat maps were useful for identifying conch habitat. A simulation was run to determine the optimal sampling design, stratified by the zones. The initial survey gave an estimate of conch density, as well as information on the different probability zones, and the zones were subsequently reshaped based on this information. This process was repeated for a series of years. The initial estimate differed greatly from the estimate based on stratification of probability zones. Additionally, the treatment of strata as a fixed variable in the estimation allowed for a greatly reduced variance estimate.

It was noted that while this is a fishery-independent example, one could see how such an approach could be adapted to use fishery-dependent information. For example, fisher knowledge could be used to specify initial probability zones, or identification of spawning areas or important historical sites.

Day 2 Breakout Group Discussions

After brief discussion of the previous presentations, the group split up into smaller breakout groups focused on three themes: 1) a discussion of stakeholder /science integration, 2) adaptive sampling approaches, and 3) management strategy evaluation exercise. The groups met for approximately one hour and then regrouped to provide summaries of their discussions.

Group 1: Stakeholder/Science Integration

This group contained participants from mostly Panama and the United States, and discussion focused on similarities between the two countries. A number of similar challenges in integrating stakeholders in science were identified. It was noted that fishing cooperatives in Panama are often difficult to work with as they are often started with NGO or international cooperation, and end promptly when resources are not sustained. Panama, similar to the U.S. Caribbean, has a void in

information particularly in the artisanal fleets, due to the large number of informal landing sites. Examples in both Panama and U.S. exists where species have been historically grouped in data collections (e.g., sharks, snappers, groupers) making single-species evaluations challenging. Finally, conflicts between local and national governments between countries can also hinder data collection and management of resources.

One solution offered was to identify community leaders who can make a case for the importance of data collection. It was also discussed that it may not be practical to use traditional assessments in some areas of the Caribbean region and that spatial approaches such as marine reserves may be easier to enforce than species-specific restrictions.

Group 2: Adaptive Sampling Approaches

This group discussed approaches similar to the work presented by Bob Glazer, and potential applications of this idea. Discussion revolved around mechanisms for initially allocating effort, how to carry out informative power analyses, and how best to make the method adaptive. The group discussed a specific case of commercial demersal fisheries in Colombia, where 10 years of artisanal data existed with CPUE records at the scale of 1 square mile resolution. In this region, one could use the fishery-dependent data to establish initial high or low density areas. Another case study discussed by the group was the Gulf of Mexico red snapper and the available spatial-temporal catch data for that fishery. The group came up with a number of additional applications for allocating survey effort, such as to locate IUU fishing, to track marine litter, and to monitor spawning aggregations. They noted that strengths in this design approach were that spatial variations could be accounted for and variance around estimates could be reduced.

Group 3: Management Strategy Evaluation

This group worked through two case studies where they considered all of the necessary steps to conduct an MSE. The first motivating example was as follows: consider that the only data you have are a time series of the catch history, with nothing else. First the group identified the

analytical methods that only require catch, and considered the catch-only MSY method for the simulation. The group used the harvest control rule developed the previous day that was then simulated. The group found that there was a breakdown in the analysis phase, in that often inaccurate estimates of MSY were produced. Ultimately, they were not able to find a system that worked well; however, they did identify at what step the management system as a whole was breaking down.

The second motivating example was the Bahamas lobster case study presented the previous day, where CPUE is used to systematically adjust catches through time. The group found that CPUE adjustments can certainly be a useful method for management in a data-limited context. However, the control rules are not the most flexible from the standpoint of the fishery, as they do not give adequate time for response in terms of changing fishing behavior and managing a business. The group considered a modified harvest control role that was fairer to the fishery – the goal was to maintain catches into the future while allowing some flexibility in yearly quotas. The revised rule was as follows: if we have years of particularly good recruits, could the fishery take advantage of that by bumping up quota. In subsequent years, the decision was re-evaluated to ensure that the correct decision was made, and downward adjustments were allowed if necessary. Essentially, this control rule creates a lag which allows fishers to plan financially for a potential downfall but also to take advantage of very good years of fishing.

Final Interactive Activity

To conclude the workshop, the terms of reference were revisited and the group was given a summary of some of the important tools that had been presented during the last two days. The group was then encouraged to think for a moment about best practices that could be gleaned from the information and experiences provided over the course of the workshop. In plenary, individuals shared their ideas which is summarized in the following list of best practices.

Best practices for optimizing sampling and matching data collection to management needs:

- Address the communication gap between scientists and stakeholders, and strive to meet in the middle. Develop tools for communication and to facilitate "speaking the same language."
- Reach out to younger generations of fishers and children to give them opportunities for participating in the scientific approach. They will go back to their families and share their experiences.
- Sometimes one must cope with the data that are available, but at the same time there needs to be planning for the data that are needed. There is an important balance in transitioning from "coping" to "planning" to use data in a more effective way. If you have good data but they don't translate to good management decisions, you don't have the data you need.
- In designing management objectives, there are many possible yet often conflicting goals. Optimal yield is not always necessarily the end goal – it could also be consistency in catch, or opportunity for recreation. These goals need to be clarified from the start.
- Management strategy evaluation is important for highlighting where steps in the management process have the potential to break down, and how biases in data inputs translate to effects on management actions.
- Any analysis in this field should be thought of as a process, not a product. The process

itself is more important than doing an analysis and putting it in a document.

- When planning for future data collection, there needs to be a vision about how circumstances may change in the future. Innovative technology will undoubtedly help to improve data collection capacity, however for data-limited regions with funding constraints, a sound business case with cost-benefits must be considered to ensure technological investment can be cost-effectively transitioned into reliable and sustained sampling operations.
- Relevant to the advances in technology, one needs to consider impacts in fisheries from fishing efficiencies and behavior. The major commercial species of today may not be targeted tomorrow.
- There is often a disconnect between the priorities within management and the design of sampling programs in support of stock assessments. It is the responsibility of managers and analysts to evaluate priorities and information gaps that drive the sampling design, and show the value of the products and services from designed data collection to the stakeholders from the beginning.
- Anecdotal information is very valuable but can be difficult to use due to lack of standardization. However, it can be complementary, and when statistical results fit with fisher observations, the combination can be very powerful.

Synthesis and Conclusions

Workshop participants were given a final moment to consider the terms of reference and how they had been met throughout the workshop. It was noted that some goals were directly addressed (*e.g.*, exploring analytical tools), whereas others were threaded throughout (*e.g.*, enhancing stakeholder input). The group was thanked for their participation and it was noted that follow-up would occur in the coming weeks. In terms of continuing work, the group was encouraged to treat the workshop series as an ongoing working group, and to keep in contact and build collaborations among individuals present. Funding is always somewhat of a limitation in building new projects; however, there are numerous opportunities for expanding such work. It was noted that some of the ideas from the 2013 workshop were written up in a proposal, which was successful and subsequently had funded some of Dr. Bill Harford's work. The facilitators also noted that they had been pushed outside of the usual comfort zone of strictly stock assessment, and had gained a great deal from working with the group. Individuals were asked to note on the evaluation form any ideas for future work that might play out into GCFI strategic projects, or the NOAA Ocean Innovation grant. The 2015 workshop was thus concluded.

Literature Cited

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Cummings, N.J., M.L. Karnauskas, W.L. Michaels, 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, Corpus Christi, TX, November 4-8, 2013. NOAA Tech. Mem. NMFS-SEFSC-661. pp. 25.

Appendix 1. List of oral presentations of the GCFI special session "Data-limited Stock Assessment"

An overview of the 2013-2015 GCFI workshops: Evaluation of stocks in data limited situations (Nancie Cummings)

Management strategy evaluation for data-limited fisheries (William Harford)

Determining effective fisheries monitoring and assessment approaches in data-limited contexts: A case study of the fisheries in Montserrat and Curaçao (Lennon R. Thomas)

Current status of the fishery of the Grouper in the State of Yucatan, Mexico, and strategy for the collection of data with participation of users (Luis Alfonso Rodriguez Gil)

Using in situ length data to determine stock status of protected aggregating fish species: a case study of Nassau grouper (*Epinephelus striatus*) (Brian Stock)

Automating fish sound recognition in spawning aggregations: Application of passive acoustics in fisheries (Michelle Scharer-Umpierre)

Cooperative Research and Conservation Program for Western Central Atlantic Spawning Aggregations (CRCP WCASA) (William Heyman)

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 for the 2015 GCFI data-limited assessment workshop

Last Name	First Name	Organization
Acosta	Alexandro	Florida Fish and Wildlife Commission
Appeldoorn	Rich	University of Puerto Rico
Beltran Turriago	Claudia Stella	Caribbean Regional Fisheries Mechanism
Brown	Jonathan	Dept. Fisheries and Wildlife, U.S. Virgin Islands
Cummings	Nancie	NOAA Fisheries, SEFSC
Del Cid	Annissamyd	Fundación MarViva, Panama
DeMaria	Don	Fisher, Panama
Duarte	Robert	Panamanian Aquatic Resources Athority, Panama
Duarte	Luis Orlando	Universidad del Magdalena, Colombia
Foley	James	Toledo Institute for Development and Environment
Garces	Humberto	University Maritima Internaccional de Panama
Garcia Moliner	Graciela	Caribbean Fisheries Management Council
Gittens	Lester	Bahamas Department of Marine Resources, Bahamas
Glazer	Robert	Florida Fish and Wildlife Commission
Godelman	Ernesto	CeDePesca, Panama
Harford	Bill	University of Miami, RSMAS
Henke	Marcos	Caribbean Fisheries Management Council
Karnauskas	Mandy	NOAA Fisheries, SEFSC
Leaf	Robert	University of Southern Mississippi
Machazeck	Marta	Union de Pescadores Artesanales Bocatoreños, Panama
Manjarrés-Martínez	Luis	Universidad del Magdalena, Colombia
McInnis	Andrew	Peace Corps, Panama
Michaels	William	NOAA Fisheries, Office Science and Technology
Murray	Peter	Caribbean Regional Fisheries Mechanism
Nunez	Anna	Panamanian Aquatic Resources Athority
Pacheco	Lucas	Fundación MarViva, Panama
Phillips	Todd	Ocean Conservancy
Pinzón	Zuleika	Ministerio de Ambiente, Panama
Pitt	Joanna	Dep. Environment and Natural Resources, Bermuda
Prada	Martha C	Blue Dream Ltd., Colombia
Rindone	Ryan	Gulf of Mexico Fishery Management Council
Rios	Adyan	NOAA Fisheries, SEFSC
Ruiz	Abel	Asociación de Pescadores Artesanales de Hicaco Panama
Seijo Gutierrez	Juan Carlos	Universidad Marista de Merida, Mexico
Semmens	Brice	Scripps institution of Oceanography, California
Silva	Miguel	The Nature Conservancy
Stock	Brian	Scripps Oceanography, UC San Diego, California
Thomas	Lennon	University of California at Santa Barbara, California
Trumble	Bob	MRAG Americas, Florida
Walker	Laverne	Caribbean Large Marine Ecosystem Project, Saint Lucia

Appendix 3. Agenda for 2015 GCFI data-limited assessment workshop

Workshop agenda: Day 1 (Monday, November 9th, 10:00am - 5pm)

10:00 - 10:10 ……...……..……..……... *Arrival*
10:10 - 10:20 Welcome, workshop theme and goal, expected products ….... Nancie Cummings
10:20 - 10:30 Pre-workshop questionnaire responses ……..……..… Mandy Karnauskas
10:30 - 11:00 Keynote talk.……..……..…..……..… Bob Trumble
11:00 - 11:30 Excel tool and interactive activity 1……...…… Adyan Rios
11:30 - 12:00 MSE Tool Example for Production Model ……..…….……..... Bill Harford
12:00 - 12:30 Regional case study 1, Bermuda...…….....…… Joanna Pitt
12:30 - 1:30 ……..…….……..…… *Lunch*
1:30 - 2:00 Harvest Control Rule interactive activity ……..……..... Nancie Cummings
2:00 - 2:15 Summarize Harvest Control Rule Activity ……...…..…….…..... Group Leads
2:15 - 2:45 Regional case study 2, Bahamas ...……...……..…..….. Lester Gittens
2:45 - 3:15 MSE and Excel; Tool Work & Fisher Breakout group discussions ……....Team
3:15 - 3:30 ……..……..…..…. *Break*
3:30 - 4:30 MSE Tool Work, Fisher, and Excel breakout group discussions .....Team
4:30 - 5:00 Activity 2 Participants input on good practices from breakout groups ….....Team
5:00 - 5:15 Summarize Interactive Activity 2 …..……..……..…….Group leads
5:15 ……..……..…….... Day 1 close
7:00 pm ……...…..……..……..…… Conference gathering

Workshop agenda: Day 2 (Tuesday, November 10th, 08:15 - 1pm)

08:30 - 08:45 Summarize Day 1 activities……..……... Nancie Cummings
08:45 - 09:00 Reflections: 2013-2014 workshops and Future Path ……. Nancie Cummings
08:45 - 09:00 Review of data limited methods since 2013 workshop ……... Mandy Karnauskas
09:00 - 10:00 Case study: use of anecdotal information to guide sampling…....…. Robert Glazer
10:15 - 10:30 ……....…….... *Break*
10:15 - 10:45 Breakout groups. ….....Team
10:45 - 11:00 MSE results for case study questions ……....……..……... Bill Harford
11:00 - 11:20 Group Plenary on tool results ...……...……. Group leads
11:20 - 11:40 Final Interactive Activity 3: Good practices flowchart design work..... Team
11:40 - 12:00 Final Plenary ……..... Group
12:00 - 12:15 ...……...Wrap up
12:15 - 12:20 ……..……..…….....……..…..... Workshop Close
12:20 - 12:30 ….....…….……..……..……..…….. Course Evaluation

Appendix 4. 2015 GCFI data-limited assessment pre-workshop questionnaire

Please indicate your name, geographical location, affiliation, and email:

1. In what capacity are you involved with fisheries management? (check all that apply)

☐ Fisheries survey design	☐ Stock assessment analyst	☐ Fishing industry
☐ Fisheries data collection	☐ Fisheries manager	☐ Fisher
☐ Conservation organization	☐ Government	

2. Are you involved in the determination of how to divide sampling resources between fishery-dependent and fishery-independent programs?

☐YES ☐NO

If YES, please briefly describe your role and type of experience:

3. What factors do you feel are important in deciding how to apportion sampling effort in your region?

4. What are the major factors impacting the decisions relating to apportioning of fisheries sampling in your region (funding, type of fishery, political pressures, etc.)?

5. Are stakeholders currently involved with the decision-making processes related to sampling programs in your region?

☐YES ☐NO

If YES, please briefly describe how stakeholders are involved:

7. Are you familiar with the concept of Management Strategy Evaluation (MSE), and have you used this technique before?

☐NO ☐YES I am familiar, NO I have not used MSE
☐YES I am familiar, YES I have used MSE

If YES, please list how you would like to see MSE used in this workshop to explore impacts on sampling decisions on management advice:

8. Please tell us about any goals that you hope to achieve from this workshop?