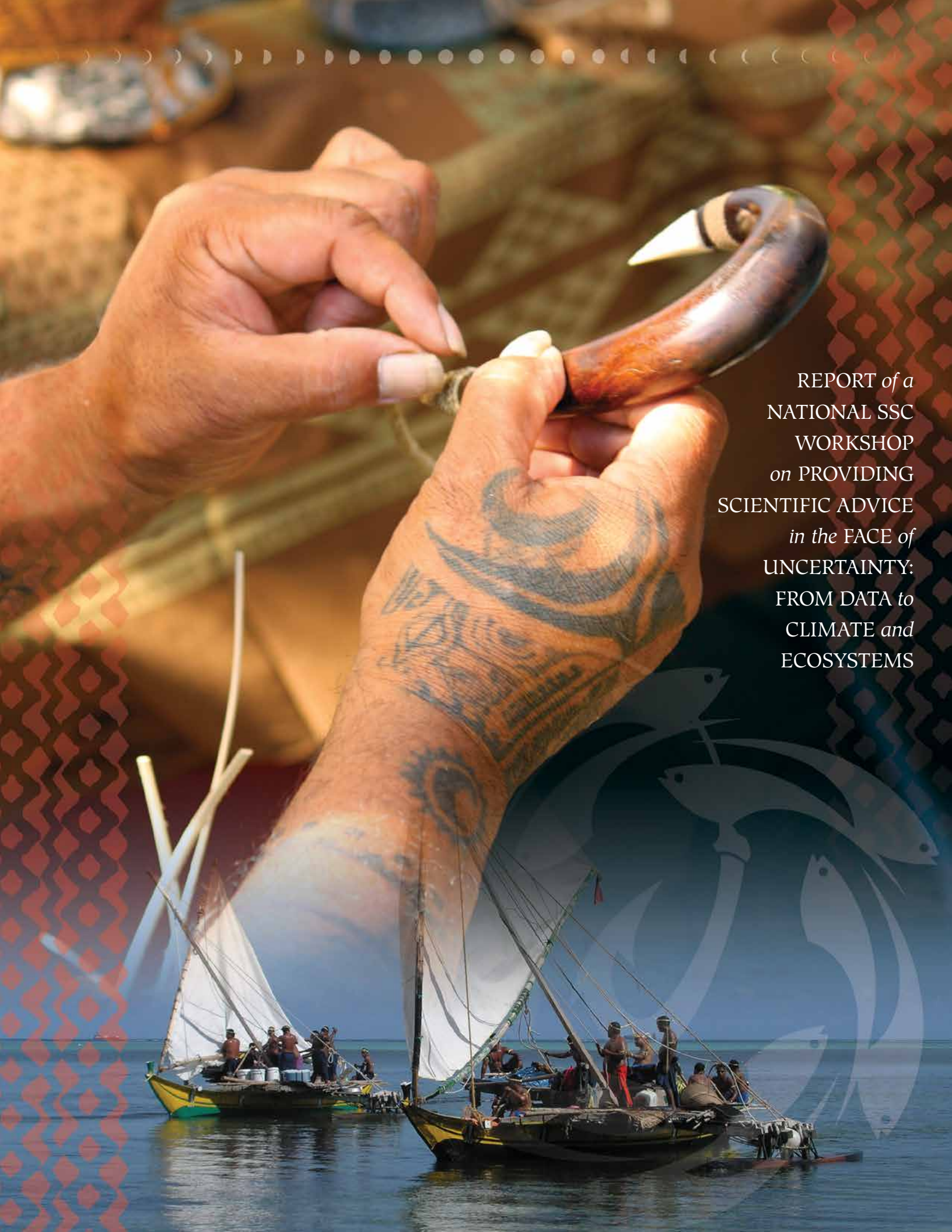

REPORT *of a* NATIONAL SSC WORKSHOP *on* PROVIDING SCIENTIFIC ADVICE *in the* FACE *of* UNCERTAINTY: FROM DATA *to* CLIMATE *and* ECOSYSTEMS

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Fifth National Meeting of the Regional Fishery Management Councils' Scientific and Statistical Committees

Hosted by the
Western Pacific Fishery Management Council
Honolulu, Hawaii
February 23–25, 2015

Report of a National SSC Workshop on Providing Scientific Advice in the Face of Uncertainty: from Data to Climate and Ecosystems

NSSC-V

CONTENTS

EXECUTIVE SUMMARY

The fifth National Scientific and Statistical Committee (NSSC) Workshop was convened to allow discussions among the eight regional Scientific and Statistical Committees (SSCs) regarding the central-theme of "*Providing Scientific Advice in the Face of Uncertainty in Data and Climate*."

The workshop aimed to initiate inter-regional discussion on five subthemes:

1. *Specifying Acceptable Biological Catch (ABC) for Data-Limited and Model-Resistant Stocks;*
2. *Implementing National Standard 2 in the Face of Uncertainty;*
3. *Evaluating Existing ABC Control Rules: Issues, Challenges and Solutions;*
4. *Incorporating Ecological, Environmental, and Climate Variability in Stock Assessment and Ecosystem-Based Fishery Management;*
5. *Building Habitat Conditions into the Stock Assessment Process and Fishery Management Strategies.*

SSCs now have several years of experience in specifying Acceptable Biological Catches (ABCs) based on deliberations in the first three NSSCs; thus, it was an appropriate an appropriate time to evaluate the performance of the Annual Catch Limit (ACL) based management process. Despite significant progress in developing the specification process, some regions are still struggling with data-poor fisheries and the difficulties of developing stock assessment and review processes. In addition to fishery-inherent challenges, regions are faced with uncertainties from climate-change related impacts and variations in habitat metrics that limit the ability to fully implement Ecosystem-Based Fishery Management (EBFM). SSCs are at different stages of ACL and EBFM implementation. Participants felt that a national discussion on the status and lessons learned in the ACL and EBFM experience would be beneficial in moving forward the science of fishery management.

Subthemes were prefaced by keynote presentations aimed at stimulating plenary discussion. The deliberations were facilitated by volunteer SSC Chairs and Dr. Sam Pooley (former director of the Pacific Island Fisheries Science Center). Facilitators requested that each SSC consider among themselves selected trigger questions (see Appendix II) and then report their findings to the plenary where discussion would continue. Reports and plenary deliberations were captured in the transcript and the notes of the rapporteurs.

Workshop key findings and potential recommendations are as follows:

1. *Specifying ABC for Data-Limited and Model-Resistant Stocks*
    a. Enhance communication to Councils and stakeholders regarding risks associated with shifting tiers, so they do not confuse the detailed quantitative nature of the higher tiers (stocks with assessments and well quantified risks) with increased rigor or performance.
    b. Invest in resources (funding and man-power) to improve the ability of regions with a significant number of data-poor stocks to collect pertinent data and regions with numerous data sources to produce and review products to comply with the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requirements in specifying ABCs.
    c. Provide more guidance to data-rich regions with "model-resistant" stocks regarding when to downgrade to data-limited approaches and the need to document unused information and the risks associated with not using it.

2. *Implementing National Standard 2 in the Face of Uncertainty*
   a. Develop procedures to deal with situations where the SSC and NMFS do not agree on the best science available.
   b. Revise the existing process to separate the review based on best available science and the recommendation for use of the information for management.

3. *Evaluating Existing ABC Control Rules: Issues, Challenges and Solutions*
   a. Report on the retrospective performance of ABCs, based on the development of consistent performance measures that are common to all regions.
   b. A generalized approach may be needed for Management Strategy Evaluations (MSEs) with specific objectives (e.g., evaluating control rules or setting overfishing limits) to allow cross regional comparisons and use.
   c. Strive for consistency in describing risks associated with ABCs across regions.

4. *Incorporating Ecological, Environmental, and Climate Variability in Stock Assessment and Ecosystem Based Fishery Management*
   a. National guidance is needed on: a) appropriate responses to sudden changes in parameters; b) a systematic approach to determining keystone species for which ecosystem-based reference points might be needed; c) costs and benefits of considering multispecies models alongside single species models during the assessment process; and d) determining when a regime shift or other major environmental change compels a change in parameter inputs and resultant reference points.
   b. Regions having adjacent jurisdictions need a mechanism for collaboration so that management strategies are consistent and conflicts in management goals are avoided, particularly when species populations shift due to climate change impacts.
   c. National guidance is needed regarding quota recommendations for stocks that have shifted distributions (due to climate change, spatial changes in productivity, etc.) into adjacent management jurisdictions.

5. Building Habitat Conditions into the Stock Assessment Process and Fishery Management Strategies
   a. An enhanced recognition of habitat condition should be factored into the stock assessment process and fishery management strategies.
   b. More information is required on the relationship between habitat attributes and stock productivity, as this information has impacts on stock assessment advice and is directly linked to ecosystem productivity.
   c. New tools are needed to analyze habitat information for use in management measures, particularly to distinguish areas of resilient essential fish habitat (EFH) from less resilient EFH in need of additional management.

PREFACE

The 2006 revisions to the Magnuson-Stevens Act (MSA) placed renewed emphasis on the role of science in the management of our Nation's living marine fishery resources. Central to this approach was the strengthening of the role of Scientific and Statistical Committees (SSCs) in the decision-making process of the eight Regional Fishery Management Councils, particularly with respect to the mandate that the Councils specify annual catch limits (ACLs) to prevent overfishing. In recognition of the increased demands placed on their SSCs in this new role, the Councils convened national meetings of the eight regional SSCs, beginning in 2008, to discuss major challenges faced by SSCs and to help develop solutions to implementing new MSA ACL requirements and related scientific issues. At the 2012 Council Coordinating Committee (CCC), the National SSC was designated as an official advisory body to the CCC on scientific issues of national significance. The Fifth National Scientific and Statistical Committee (NSSC) Workshop convened on February 23–25, 2015, is the first workshop held in an advisory body capacity and the recommendations from this workshop will be presented to the CCC for action.

In 2008 the Western Pacific Council (WPFMC) hosted the First NSSC Workshop, where SSC operating procedures and potential approaches to addressing the new ACL requirements of the revised MSA were discussed. In 2009 a second Workshop was hosted by the Caribbean Fishery Management Council (CFMC) to discuss the technical aspects of establishing scientifically-based annual catch limits. In 2010 the South Atlantic Council (SAFMC) hosted the Third NSSC Workshop where representatives reported on progress toward implementing ABC control rules, which form the basis for providing fishing level recommendations to the Councils. At that meeting there also was discussion of regional stock assessment peer review programs and the role of SSCs in those processes. Discussion at the end of the 2010 Workshop highlighted the fact that the first three national workshops were focused almost exclusively on biological issues related to ABC control rule development and implementation. Only limited discussion took place about the role of the SSCs in providing social and economic advice to the Councils. The Fourth NSSC Workshop, hosted by the Mid-Atlantic Fishery Management Council (MAFMC), was convened in 2011 to provide an opportunity for the eight SSCs to discuss ecosystem considerations in fishery management and to discuss the role of social sciences in both traditional single-species and ecosystem-based fisheries management (EBFM).

The Fifth National SSC Workshop focuses on the central theme of "providing scientific advice in the face of uncertainty in data and climate." The workshop program was developed by the NSSC Steering Committee comprised of the SSC Chairs, staff from Regional Fishery Management Councils, and a representative from the National Marine Fisheries Service (NMFS) Office of Science and Technology (OST).

The workshop was led by the Western Pacific SSC Chair, Dr. Charles Daxboeck. Eleven keynote speakers covered topics relevant to each subtheme of the Workshop. In that regard thanks are due to Dr. Malcolm Haddon, Dr. James Thorson, Dr. Rick Methot, Mr. Eric Schwaab, Dr. André Punt, Dr. Michael Wilberg, Dr. Jeffrey Polovina, Dr. Anne Hollowed, Dr. Jonathan Hare, Dr. Thomas Noji, and Dr. John Manderson for setting the stage for plenary discussions.

This report is based on abstracts of presentations provided by keynote speakers, as well as a recorded transcript and the rapporteur notes of regional Council staff members, including Joshua DeMello, John DeVore, Paul Dalzell, Graciela Garcia-Moliner, John Froeschke, Mike Errigo, Richard Seagraves, Eric Kingma, Chris Kellogg, Rebecca Walker, David Witherell, Christopher Hawkins, and Steven Atran. These individuals deserve special thanks along with Samuel Pooley, Meisha Key, Jake Kritzer, and John Boreman who facilitated the plenary discussions. Marlowe Sabater and Paul Dalzell edited and formatted the submissions for consistency and assembled the final report. This report benefited from review comments made by Steve Atran, David Witherell, Richard Seagraves and John Boreman. Outstanding logistical and administrative support was provided by Asuka Ishizaki and Pacific RIM LLC, while Loren Bullard provided excellent photographic support during the workshop.

Welcoming Remarks of Kitty Simonds to the 5th National SSC

It is a great pleasure once again to welcome SSC members and staff from the nation's eight Fishery Management Councils to Honolulu for this, the fifth National SSC Meeting. Some of you here will remember that we held the first National SSC in Honolulu in November 2008. I recall that that meeting was a success although we held it under very trying conditions after our computer network had crashed and was still being rebuilt and repaired.

At that meeting, the SSC members discussed SSC structure and practices, as well as the role of SSC in peer reviews and establishment of catch limits. At that time, 2008, the Magnuson-Stevens Act had recently been reauthorized. This 2006 reauthorization had shifted the landscape of federal fisheries management in the US by handing a great responsibility to the 8 SSCs, namely the establishment of Acceptable Biological Catches.

Kitty Simonds and Marlowe Sabater of Honolulu, Hawaii

The incorporation of management by annual catch limits in MSA National Standard 1 reflected the growing intolerance for overfishing by Congress. In the early 1990s, Congress required Councils to have an objective and measurable definition of overfishing. This was followed in the 1996 reauthorization by the requirement for biomass and fishing-mortality based control rules, and ultimately to catch limitation in the 2006 reauthorization.

The next two National SSCs in 2009 and 2010 dealt specifically with management of fisheries by catch limits, a topic that occupied all Councils but especially those with a plethora of data poor stocks. It was only by the fourth National SSC in 2011 that the topics shifted from catch limitation to ecosystem and social science considerations in fisheries management.

This meeting has the theme, "Providing Scientific Advice in the Face of Uncertainty: from Data to Climate and Ecosystems". While it contains sessions on fishery management by catch limits, this is ten years on from the 2006 MSA reauthorization. Unlike previous meetings where we were preparing for the future, we now have several years of experience in managing fisheries with catch limits.

The agenda also contains sessions on incorporating ecological, environmental and climate variability into stock assessments. This is important as recently published scientific papers have shown that fish stock productivity may not be related to stock abundance nor may spawning biomass be the driver of recruitment dynamics. As such, fisheries managers need to recognize that irregular changes in productivity are common and that harvest regulation and management targets may need to be adjusted whenever productivity changes.

Another development that has occurred since the first National SSC meeting is the recommendation by the May 2012 Council Coordination Committee meeting to formalize the National SSC as an advisory body to the CCC. Your findings will be part of the agenda for the May 2015 CCC meeting and subsequent National SSCs will also be part of the CCC agenda.

In my welcoming remarks at the first National SSC, I expressed a warm aloha to all participants and observers and encouraged SSC members to meet together frequently to share ideas and learn from each other's successes. I repeat those sentiments and wish you much aloha and hope you have a successful meeting and exchange of information and ideas.

SUBTHEME 1.a:

Specifying Acceptable Biological Catch for Data-Limited and Model-Resistant Stocks

Keynote Presentation: Managing Data-poor Fisheries Down Under

Speaker: **MALCOLM HADDON**, Commonwealth Scientific and Industrial Research Organization (CSIRO)

Influential FAO documents in the mid-1990s appear to have stimulated the evolution of modern harvest strategies focused around target and limit reference points along the scales of different stock performance measures combined with harvest control rules that define management actions in the face of an assessment of the stock status relative to those pre-defined reference points. This approach has been successful; the Commonwealth Harvest Strategy Policy was introduced in Australia in 2007, and 2013 was the first year that no stocks were classified as being subject to over-fishing and only 6 were classified as over-fished. Such successes appear to have stimulated a wish to expand the application of government fishery related policies, which means that more fisheries will become formally managed to achieve the objectives of such policies. To fit into the agreed process this in turn means that there is a need to assess the status of many more stocks. Naturally, the earlier work would have focused mostly on those species considered to be important, either financially or socially; this is certainly the case in Australia. It is also the case that those species initially considered less important generally have not been subject to any systematic data collection. Despite this lack of information, to meet current policy some way of assessing a stock's relative status through time is required; but how is that to be done if a stock is data-poor?

Malcolm Haddon

For data-poor fisheries, difficulties can arise in almost every component of its harvest strategy- for example, irregular or no monitoring means time series are rare, any assessment method is undertaken with an unknown degree of uncertainty, reference points are poorly defined and associated control rules do not necessarily address risk clearly. This latter is a problem in Australia where an explicit component of the present Harvest Strategy Policy is the application of a consistent degree of risk across all fisheries, irrespective of fishery type.

Recently many data-poor assessment methods have been developed and some have been tested using management strategy evaluation. Where there is catch and an index of relative abundance then a simple model of the dynamics can be fitted (e.g. surplus production), where there is only catch then consistency with a simple model can be used (e.g. Catch-MSY) to bound the dynamics, and where a model cannot be fitted then an empirical harvest strategy can be used. The use of a tiered system of assessment methods and associated control rules allows for the development of detailed, integrated stock assessments (Tier 0 and 1) down to the lowest Tiers where data is limited to catch rates and catches, or even just catches (Tiers 6 and 7). Below these tiers is the Ecological Risk Assessment, which aims to determine whether there are particular species that are exceptionally vulnerable to the effects of fishing.

Australian Harvest Strategy Policy (Distilled)

- Maintain stocks, on average, at $B_{TARG} = B_{MEY}$
- Ensure stocks remain above B_{LIM} (or proxy), at least 90% of the time.
- $B_{TARG} = 48\%B_0$ $B_{LIM} = 20\%B_0$
- For highly variable species (naturally breach B_{LIM}), HS must be consistent with Policy intent (and data-poor)
- B_{LIM} (or proxy) $\geq \frac{1}{2} B_{MSY}$ (or proxy).
- $B_{TARG} \sim 1.2B_{TARG} \sim B_{40\%}$
- In meeting all objectives HSs also required to consider ecosystem interactions.

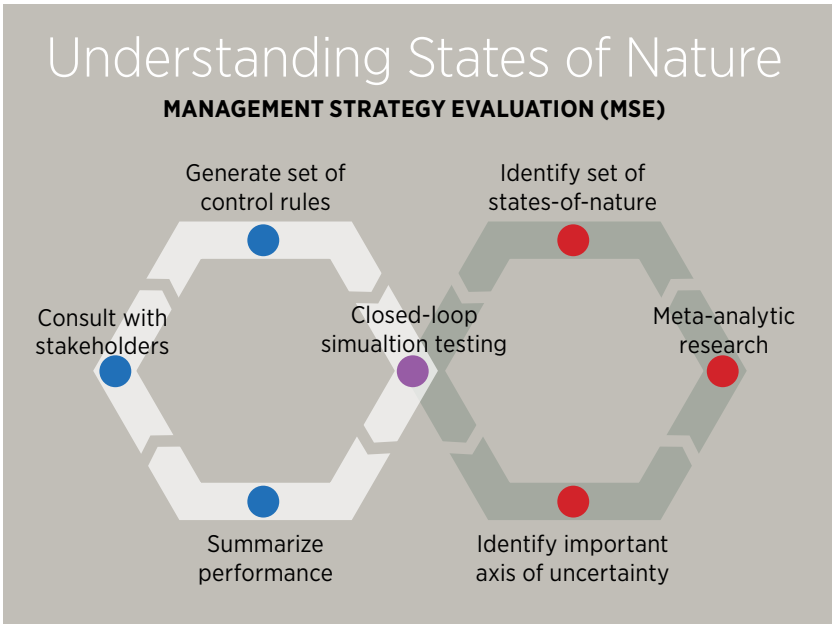
Keynote Presentation: Progress and Roadblocks in the Estimation of Stock Status and Catch Limits for Global Fisheries

Speaker: **JAMES THORSON**, NMFS—Northwest Fisheries Science Center

Keynote speaker, James Thorson, from NMFS, Northwest Fisheries Science Center

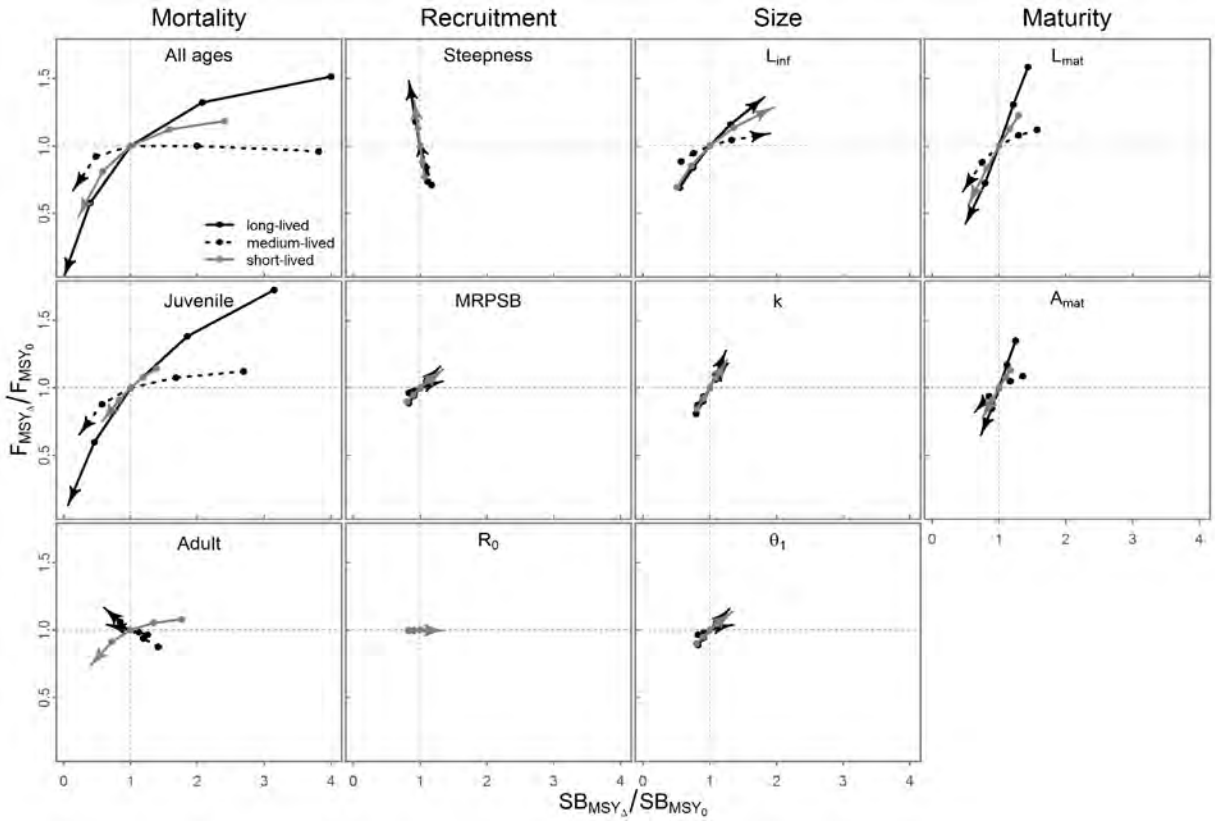
Interest among NMFS researchers in estimating catch limits for previously unassessed stocks has exploded since the Magnuson-Stevens Reauthorization in 2007, and other scientific bodies also have longstanding interest in global fisheries status (e.g., the Food and Agriculture Organization). Stocks may be unassessed for a variety of reasons, including low economic value, limited or spatially unsuitable data sources, inability to fit available assessment models, etc., and we will collectively call these "data-poor" stocks. Many methods have been developed in the last decade for assessing data-poor stocks, and the evaluation of these methods is ongoing.

In this talk, we provide an up-to-date bestiary of methods for estimating status and/or catch limits for data-poor stocks. We start by introducing a distinction between algorithmic and statistical methods for estimating status and/or catch limits for data-poor fisheries, where statistical methods include both mechanistic and meta-analytic approaches. We then outline recent developments in combining meta-analytic



SOURCE: NOAA FISHERIES. PUNT, A.E. 2008. REFOCUSING STOCK ASSESSMENT IN SUPPORT OF POLICY EVALUATION. IN FISHERIES FOR GLOBAL WELFARE AND ENVIRONMENT. EDITED BY K. TSUKAMOTO, T. KAWAMURA, T. TAKEUCHI, T.D. BEARD, AND M.J. KAISER. TERRAPUB, TOKYO, PP. 139–152.

Sensitivity of biological reference points to time-varying biological parameters



and mechanistic approaches within statistical models. We also discuss efforts to incorporate opportunistic (composition or citizen-science) data when available. We conclude by summarizing ongoing efforts to evaluate performance of these methods, either via simulation or by comparison with regional or global estimates arising from data-rich assessments. Throughout, we offer our personal perspectives on future directions for data-poor assessments, including the importance of spatial approaches to data-poor stocks, the role of flexible software tools, and the benefit of improved linkages with data-rich models.

There are three broad themes for improving our understanding of stock status:

- Need improved understanding of what is estimate-able under what conditions,
- Need improved knowledge of "states of nature,"
- Need standardized assessment tools and evaluation routines.

1. Progress was made on all three themes but there is a need to prioritize research

2. Difficult to know how to "roll out" these tools
   - Region-specific interpretation of models
   - Reviewers have different expectations of an "acceptable" model
   - Partner groups want their data to be used

3. Data moderate methods are available
   - Their interpretation is being discussed
   - Difficult to review
   - Difficult to guard against model creep

Round Robin Session: Setting ABCs for Data-Limited and Model-Resistant Stocks (with emphasis on problems in the specification process for stocks with limited to no data or with data that is not usable for the existing modeling framework)

NORTH PACIFIC FISHERY MANAGEMENT COUNCIL

Uncertainty and Risk

There are several different approaches to incorporating uncertainty and translating that into risk relative to setting catch limits for North Pacific fisheries. The tier system

NPFMC representatives Brad Harris and Farron Wallace

control rules set buffers between OFL and maximum ABC, such that the buffers are intended to be larger for stocks in the higher tiers (stocks with less information). On average, buffers are 8% at Tier 1, 17% at Tier 3, and 25% at Tier 5, although the size of the buffer varies between stocks for Tier 1 stocks. The FMP authorizes the SSC to set ABC below the maximum specified using the tier formulas. These downward adjustments to the ABC have been based on formal or informal assessments of uncertainty, including scientific judgment. For example, when setting the annual catch specification for 2015 Eastern Bering Sea pollock, the SSC specified a large reduction from the maximum allowed ABC, based on uncertainty about the stock projections and the history of sustainable catches. Maximum ABC based on Tier 1 calculation would have resulted in an ABC of 2.9 million t, which was more than double the prior year ABC of 1.37 million t.

The SSC noted that this stock has been stable with catches at about 1.2 million t/year since 1977, and similarly, replacement yield and the 5-year average F rate would result in an ABC of about 1.4 million t. The SSC set the ABC for this stock using the tier 3 maximum value of 1.637 million t. The pollock fishing industry supported this approach.

Approach to ABC specification for data-limited stocks

While the North Pacific region is considered data-rich, very little is known about the abundance or the biology of many (particularly non-target) species. Setting ABCs for these stocks has evolved over time as more information has become available. Several species with limited information are managed as an assemblage with other species having similar life histories. For example, there are 15 flatfish species in the BSAI "Other Flatfish" assemblage, with ABC specified based on the component survey biomass, using natural mortality rates for the two species where these rates have been estimated. In the case of groundfish, most stocks managed in an assemblage are not subject to directed fisheries, but are incidentally caught in fisheries for other targets.

Some stocks are difficult to model due to data limitations. For a few stocks with directed fisheries (e.g., AI golden king crab, scallops), data are insufficient to determine biomass. For other stocks (e.g., octopus, sharks), the surveys may cover the range of the stock, but the survey is unsuitable for use as an indicator of biomass due to the gear used. Species with short life spans (e.g., squid) are also difficult to model and project biomass. Various approaches have been taken to address these limitations in establishing ABCs for these stocks. Many data limited stocks are managed with a Tier 5 control rule (ABC<0.75*M*B), and data poor stocks without reliable biomass estimates

fall into Tier 6 control rule (ABC<0.75*OFL, where OFL is average catch from 1978-1995, or an alternative value established by the SSC).

One creative example is the method used in recent years for setting ABC for BSAI Octopus. Rather than using a highly uncertain biomass estimate from the trawl survey, or using average catch in past fisheries, ABC is based on the consumption of octopus by Pacific cod, a major predator of octopus. Stomach sampling had shown that cod consume a geometric mean of 3,452 t of octopus per year. This number is used as the OFL, and ABC is set at 75% of OFL.

Coordinating State-Federal policies for ACL-based management

Many fisheries off the coast of Alaska occur in both State waters and Federal waters. In most cases, catches of a species that occur in State waters accrue towards the Federal TAC. Some stocks (e.g., lingcod, black rockfish) are not in the FMP and thus subject to only State management, and all catches are accounted toward State harvest limits even if caught in Federal waters. For FMP stocks where the State also manages a directed fishery (e.g., Pacific cod, AI sablefish, PWS pollock) all catch accrues to the ABC established by the SSC, with separate TACs and other regulations for State water fisheries and Federal water fisheries. For these split stocks, the Council simply reduces the TAC from the ABC to account for State managed, State water fisheries. These percentages are specified in State regulations as a percentage of the Federal ABC for that stock/management area. For example, 3% of the Bering Sea and Aleutian Islands Pacific cod ABC is subtracted from the ABCs to account for the State managed fisheries in the Aleutian Islands. State-managed fisheries occur only in State waters, usually after the Federal season is closed, and all catch accrues towards the State harvest limit. Federal fisheries occur in both Federal and State waters during the Federal seasons, and all catches accrue towards the Federal TAC.

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

The Western Pacific Council divides its fisheries into three primary sections—pelagic, bottomfish, reef and small coastal pelagics. The pelagic fisheries are mostly dealt with by Regional Fishery Management Organizations (RFMOs), and the SSC provides advice to the Council on these species but does not become directly involved in their management. Federal implementation of RFMO mandated catch/effort limits passes through the SSC which provides comment and advice to the Council regarding the interpretation and impact of RFMO assessments and management measures.

Bottomfish is assessed as a stock assemblage and the Western Pacific Stock Assessment Review (SAR) process provides overall review of these assessments. The reef and small coastal pelagic species are almost entirely data-poor stocks. The SSC examines these species based on stock assemblages, largely due to the insufficiency of data quality and coverage.

The SSC has used a biomass-augmented MSY model, which is a modification of the Martell-Froese model, to estimate reef and small coastal pelagic resources. All stock

WPRFMC Group during a breakout session

assessments are conducted by the Pacific Islands Fisheries Science Center (PIFSC). Other than active review by SSC members there is limited capability within the State and Territories to assist in that process. All assessments conducted to date have incorporated variations of the dynamic stock production model. Fishery-dependent data is used in almost all instances. The only use of the fishery-independent data is in regard to the coral reef species. In data-poor situations the SSC has depended primarily on the seventy-fifth percentile of the catch time series as the basis for ABC. In some cases proxies have been employed to arrive at ABCs for data-poor stocks.

Measures of statistical uncertainty are addressed in models for the few resources where they can be applied. A P-Star Working Group has been established to evaluate scientific uncertainty.

We also have a Social, Economic and Ecological Management (SEEM) Working Group, that provides uncertainty estimates from those perspectives, and these are incorporated into the buffers that are put in place for the management limits.

The fishery-independent data is limited exclusively to shallow water coral reef surveys, and the uncertainty regarding those estimates is not well developed at this point, but improvements are underway in that area.

The SSC has a five tier system, ranging from the probabilistic approach down to very data-poor situations. There are only a few stocks in higher tiers where modeling tools can be used. Even in some of those circumstances, the SSC continues to question whether the data is actually appropriate for that level of analysis.

The SSC would like to start doing a better job with the data-poor stocks, and the SSC and Western Pacific Council would like to receive more assistance at the national level in regard to monitoring these stocks. There is a need for continued development of data-poor, "quick-and-dirty-type" assessments because of the nature of fisheries and the state of data quality in the Western Pacific Region.

Species identification is a problematic issue in the smaller island areas. It can only be accomplished through better state and territorial collaboration. Presently the only state/federal management coordination is in the Main Hawaiian Islands fishery for the Deep Seven Bottomfish complex. There are no similar arrangements for other areas of Council jurisdiction, although efforts are being made to expand collaboration into additional island areas.

PACIFIC FISHERY MANAGEMENT COUNCIL

This synopsis focused primarily on groundfish and coastal pelagic species (CPS). The Pacific Council's SSC uses categories for setting ABCs. Category 1 applies to data-rich stocks, and the OFL is based on the FMSY or FMSY proxy. We generally use the stock synthesis model for Category 1 stocks.

Category 2 applies to data-moderate stocks. The OFL is derived from model output or natural mortality under that category. An example would be XDBSRA (extension of the Depleted Biomass Stock Reduction Analysis).

Then the majority of Pacific Council manage stocks are Category 3 or data-poor stocks. The OFLs are derived from data-poor methods, such as DCAC (Depletion-Corrected Average Catch) using historical catches only. Those methods are only used for setting the OFL and not for status determination.

To capture the uncertainty, the SSCs initial focus was on current biomass, while being aware that there is a lot more uncertainties in FMSY or forecasting the ecosystem. There is a great deal of variation among stock assessments which capture a wide variety of the sources of uncertainty. These include the data used, modeling software used, model specifications, priors, the team that conducted the work and the STAR Panel reviewed the assessment.

The Ralston, et al., paper was used to determine scientific uncertainty. A sigma value was determined through a meta-analysis of multiple assessments of all of the data-rich groundfish and CPS stocks. Sigma for our Category 1 stocks

PFMC representatives Meisha Key and Will Satterthwaite

is 0.36. This is then doubled that and quadrupled that for data-moderate and data-poor stocks respectively. This is a rather ad hoc approach. A lot more work has to be conducted to improve the evaluation of uncertainty.

The P-star value adopted is a decision made by the Council. Generally, the Council is risk-tolerant and will set P-star at 0.45 unless the Council wants to be more precautionary and have a bigger buffer.

For example, , if the Council chose a P-Star of 0.45 for a Category 1 stock there would be a 4.4 percent buffer. Additionally, if a stock has been assessed in the Category 1 and the sigma value is higher than the 0.36, the numbers would be recalculated to provide bigger buffer. The aurora rockfish assessment had a 0.39 sigma value from the assessment model, which translated to a 4.8 percent buffer.

For a Category 2 stock, if the Council chose a 0.4 P-star, that would be a 16.7 percent buffer. In the case of a Category 3 stock, this would be a 30.6 percent buffer.

For groundfish, the target reference point is 40 percent of spawning biomass, also known as the 40/10 control rule, where the combination of sigma and P-star value provides the ABC buffer. Additionally, if the spawning biomass falls below 40 percent there is another buffer for the ACL values.

For flatfish stocks managed by the Pacific Council, this is more of a 25/5 control rule. The State of California has a more conservative 60/20 Harvest Control Rule that can be used for the state species.

The stock complexes are the majority of the data-poor species, and these are grouped these based on similar life histories, distributions, habitats, etc. The OFLs and ABCs, ACLs, are all designated for a complex as a whole.

There are many stocks, minor nearshore, shelf and slope species, north and south of Mendocino at 40/10. The SSC has conducted a great deal of re-evaluation of these complexes, and the only change made was in Other Fish Category. This initially comprised 10 stocks, and now comprises only three stocks.

For nearshore species, there is joint jurisdiction for these species between States and Federal fishery management authorities. They work collaboratively in managing these species. The States typically follow the federal policy, unless there is a desire for a more precautionary approach such as California's 60/20 Harvest Control Rule.

Our Council and advisory bodies are represented by state and federal representatives, and state scientists are also involved in evaluating methods and conducting stock assessments and other analyses with their federal counterparts. Additionally, if they wish to, the States can set Harvest Guidelines.

GULF OF MEXICO FISHERY MANAGEMENT COUNCIL

The Gulf of Mexico Fishery Management Council manages reef fish, coastal migratory pelagics, red drum, shrimp and spiny lobster. The most diverse assemblage occurs in the Reef Fish FMP with 31 species.

Overall, the reef fish and coastal pelagics, for the most part, are assessed with robust assessment techniques to the extent possible. However, only about 30 percent of the stocks in the Gulf region are data-rich enough to be assessed with these robust techniques. Further, the greater amberjack is perhaps the one species in the region that might be considered to be model-resistant. However, it may be an example where

too much is being asked of the data in trying to force it into robust-type assessment models.

An example of state and federal cooperation is the red drum. This is a coastal Sciaenops species which recruits to inshore nursery areas and then moves offshore later in life. This is mostly managed by the individual Gulf States, and the Gulf States Marine Fisheries Commission. The goal for red drum management is to have

GMFMC Group during a breakout session

30 percent escapement from these inshore areas to offshore. There has been a federal closure for red drum since the mid-1980s, which was established due to a ramping up of a purse seine fishery that rapidly depleted the stock.

Red drum management is contentious. The SSC is often asked by the Council whether there are sufficient data to conduct a stock assessment in federal waters, due to the mid-1980s moratorium. There has been some experimental research fishing for red drum. But this is data-limited compared to fairly data-rich in state waters.

Shrimp are an example of joint federal and state management. There are extensive inshore fisheries for the penaeid shrimps. One of the best examples of federal and state cooperation with shrimp is the Texas Closure. The Texas shelf is closed to shrimp fishing and then opened in mid-summer once a certain size of shrimp are encountered in Gulf estuaries.

The Gulf SSC estimates the OFL and ABC for shrimps but there is no ACL as this is a species with an annual lifespan and is thus exempt from ACL specification.

Spiny lobster is another of the invertebrate fisheries that occur in federal waters in the region. They are somewhat distinct in that it is estimated that South Florida is really a sink population with recruitment supplemented from sources outside Florida. Spiny lobster is mostly managed toward maximizing yield per recruit.

The Gulf SSC has three tiers with respect to data richness. Tier 1 is a data-rich approach or information. Tier 2 is data-moderate, though there have not been any Tier 2 assessments. The data poor stocks are divided into two sub-tiers, Tier 3A and Tier 3B.

For Tier 3A and Tier 3B stocks, there are no assessments available, but landings data do exist. The difference is in Tier 3A stocks, the biomass appears to have been stable or increasing over some period of recent landings and this is based on expert opinion. The OFL is set as equal to the mean of the catch time series, plus two standard deviations. ABC is set between the mean and the mean plus 1.5 standard deviations of landings. Again, that range can be based on expert opinion.

The difference between Tier 3B and Tier 3A is that in Tier 3B stocks recent landings may be unsustainable and again expert opinion comes into play. The OFL is established as the mean of the landings time series, and then ABC is set at between 65 percent and 100 percent of the mean of that landings time series.

In the Gulf Region there are several data-deficient or data-limited stocks managed as stock complexes. These all exist within the Reef Fish FMP. The complexes are tilefish, deep-water groupers, and other shallow-water groupers. Other complexes include midwater snapper, silk and wenchman snappers and jacks. Several of these reef fish species have low individual landings or sometimes highly variable landings. Aggregating these species into stock complexes enables the tracking of ACL performance for groups of fish that individually could have very variable landings among years. Among the reef fish, however, red grouper and gag both have ABC and ACLs set individually.

There has been substantial discussion in the Gulf Region about alternative data-limited approaches. A January 2014 workshop on data-limited approaches recommended devoting a SEDAR (Southeast Data Assessment Review) Workshop to data-limited methods. The workshop goal then would be to evaluate data-limited methods with the OFLs and ABCs produced with robust assessment techniques for data-rich stocks. This SEDAR workshop may take place in 2016.

It was noted that in the southeast, there are three Councils that are served by a single Fisheries Science Center. The Southeast Fisheries Science Center provides assessment material for the Caribbean, the South Atlantic and the Gulf of Mexico.

In the Gulf Region and the southeast US as a whole, there is uncertainty that is imparted into the stock assessment process, whether with respect to data-limited types of methodologies or data-rich in recreational landings estimates. Much of this uncertainty arises from recreational fisheries, which are a large component of the landings.

There is a significant degree of uncertainty about the outputs of recreational fishery data collection programs, initially Marine Recreational Fishery Statistics Survey (MRFSS) and now Marine Recreational Information Program (MRIP). There have been some re-calibrations that are hindcasting corrections to what may be better approaches to estimating catch and effort in recreational fisheries. But every time when those iterations occur, ABCs and ACLs that are based on historical landings have to be recomputed.

The coefficients of variation (CVs) are often 1.0 or greater from the recreational surveys. As such, this changes the perception even for data-rich species of the productivity of the population of the stock in question. This is not unique to the Gulf, but clearly is distinctive of the region and it affects data-rich species. Further, this has serious implications because of the amount of uncertainty when catch data are used to compute estimates of OFL and ABC for data-limited stocks.

CARIBBEAN FISHERY MANAGEMENT COUNCIL

Some background was given on the components of the US Caribbean region. The US Virgin Islands has a standard three-mile local territorial limit. But Puerto Rico has a nine-nautical mile territorial limit. As a consequence almost all the reef shallow shelf around Puerto Rico is in local waters. So there are issues in the compatibility in the local jurisdictions in terms of how effective federal management measures can be.

CFMC Group during a breakout session

The Caribbean federally managed fisheries are subject to the SEDAR process but this has not yet resulted in any estimates of reference points. All of Caribbean stocks are data-poor. There are a number of stocks that were considered overfished and were closed as a consequence. These include the Nassau grouper and goliath grouper, which are totally closed both in federal and territorial waters. The large parrotfish are closed in the EEZ, but not yet in the territorial waters. Queen conch is closed in the EEZ, except in St. Croix in the area of Lang Bank.

The Grouper Unit 4 complex comprising deep, yellowfin, black, red and tiger groupers, is open for fishing, as is the Snapper Unit 1, which includes medium-deep-water snappers, the silk and vermillion snappers. Everything is based on average catch from periods where the catch levels appear to have been fairly steady. The years used are different from between Puerto Rico and Virgin Islands for a variety of reasons. One has to do with when things were stable. Another has to do with the nature of the data.

Recreational data for Puerto Rico was only available since 2000, and there is no recreational data available for the Virgin Islands. In Puerto Rico there is average catch for the commercial fisheries and an average catch for the recreational fisheries. Those are combined to generate the OFL.

For the Virgin Islands, only the average commercial catch is used since there is no recreational catch data. Naturally, this is a major source of uncertainty. The ABC was set as a function of the OFL.

All of the remaining stocks in the Caribbean are not considered to be overfished, but this evaluation is subject to a high degree of uncertainty. Many of them are not targeted species, with the exception of spiny lobster, which is largely a heavily-targeted species. The OFLs were set by average commercial catch in the Virgin Islands, and in Puerto Rico median catch was used, which tends to minimize the inter annual fluctuations. The ABCs were set equal to the OFL since it was believed that overfishing was not occurring.

There were two exceptions to this, wee the surgeonfish (Acanthuridae) and angelfish (Pomacanthidae). Acanthurids are herbivores, which are important for controlling algal growth on reefs. Pomacanthids are spongivores, also important for ecological functions on reefs. Due to the ecological importance of these two families of reef fish, the ABC was set particularly lower than the OFL.

The issues that we're facing in terms of uncertainties is the aggregation of stock complexes at the multi-species family level, e.g. the grunts, the triggerfish, the filefish etc. There is no option but to do this given the nature of the data where fish catches are reported at the family level. In some cases, these landings may be predominantly one species, so the landings could be treated as a single species, but data limitations still apply.

The use of average catch implies that half of the time there is going to be overfishing. But there really isn't any basis for assuming that Caribbean Region OFLs, which are based on average catch have any relationship to MSY, and that's obviously a large source of uncertainty. Further, the average yield that would be obtained under a constant catch management regime ought to be lower than what would be obtained by a constant FMSY management regime, and has a kind of buffer built into it.

SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL

Many of the points made for the Gulf Council's Fishery Management Plan and situation with the fisheries there and the Fishery Management Plans are also applicable to the South Atlantic. The South Atlantic Region shares that same Science Center, and operates around the same suite of species and under the same sort of ecological conditions as in the Gulf.

The South Atlantic Council has Fishery Management Plans for coastal pelagics, shrimp, snapper, grouper, spiny lobster, dolphin/wahoo and golden crab. There are also Fishery Management Plans that deal explicitly with habitat, with coral and the pelagic sargassum habitat.

SAFMC representatives Marcel Reichert, Luiz Barbieri and Steve Cadrin

The South Atlantic Council has to deal with more than 70 stocks through its FMPs. Most of the stocks are considered data-poor. Moreover, a large proportion of the catch is also landed by a substantial recreational sector, which creates a number of difficulties. In Florida alone there are 25 million saltwater fishing trips estimated per year, which is a huge number to sample. This is complicated further by different types of access points where there are private docks and private access points where people fish from that are almost impossible to be properly sampled. This large recreational sector and the problems inherent with sampling those types of fisheries really create an uncertainty that is very difficult to deal with.

Of the more than 70 stocks managed by the South Atlantic Council, there are only quantitative assessments for 20 stocks of those, and 15 stocks represent 80 percent of the landings. This is problematic since the South Atlantic Council tries to address management concerns and some stakeholder pressure issues to stay on top of those few stocks that need more quantitative assessments and updates on catch level recommendations. At the same time some of the other stocks that are data-poor are not being addressed to the level that they should be.

The South Atlantic Council has a Tier system similar to other Councils. Tier 1 stocks are data-rich, and quantitative assessments are conducted, where the P-Star approach can be applied. Only 20 stocks are currently in Tier 1.

Tier 2 and Tier 3 stocks are where methods that are not as quantitative are used as with Tier 1 stocks. Potentially, the P-Star approach can be applied and have a Council risk tolerance level inserted into catch level recommendations. However, the South Atlantic Council SSC has been unsuccessful in accomplishing either one of those methods. The Southeast Science Center has not been able to produce the quantitative analysis associated with these methods.

This is due to a number of different reasons. Firstly, the characteristics of the fisheries mean that there are incomplete histories of catch for the entire time table for those fisheries. Secondly life history characteristics are missing would that qualify them for the application of DCAC methodology. As such no stocks are currently in those tiers.

In Tier 4 there are 14 stocks that that can make use of Only Reliable Catch Series (ORCS) approach. The South Atlantic Council has been using ORCS primarily for catch level recommendations setting ABC for data-poor, model-resistant stocks.

The stocks in Tier 5 do not even qualify for the ORCS approach because the time series of landings are too unreliable. In this case, the SSC use a decision tree approach that takes some other criteria into account and documents the SSC decisions. This is an ad hoc approach where the SSC applies its professional scientific judgment in making some choices to come up with a catch level recommendation for the Council. At this point there are 21 stocks that are in that tier.

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

The Mid-Atlantic Council SSC is currently in a process of looking at the Council control rules and taking a hard look at the different levels for assigning ABCs, and the terminology in particular.

As part of the process, the last SSC meeting in 2014 included a half-day workshop on the ABC control rules with the lead assessment scientists from the Center responsible for the assessments on Mid-Atlantic stocks. Among the workshop outcomes was the recognition of the need to improve the communication and transfer of information on what is important to the SSC in an assessment, and what the Center was capable of providing.

Another outcome was the preservation of the four-level approach to setting our ABCs that have already been described in the past SSC workshops. One important outcome of the workshop was that assigning stocks to Levels 1, 2, 3, 4 gives the wrong impression to people and the wrong perception on the part of Council members on what these tiers or levels really represent. What they represent is the information at hand to establish an ABC, and depending on the amount of information it will fall into one of those four categories.

There was a misperception by the Council that if a stock is moved successively up a level, then this would lead to the assignment of higher quotas. This is a false impression because more knowledge about the uncertainty in a stock assessment may lead to lower rather than higher quotas.

This happened with golden tilefish, which was moved from a Level 4 to a Level 3, and the quota dropped by a hundred metric tons a year in a 800-900 metric ton fishery. This was a reason the SSC wanted to avoid using these levels as some form of a grading system.

Further, it was also noted that some stocks can be managed quite well as a data-poor stock because it would take considerable personnel and financial resources to move a stock up a level. Instead, the SSC should use the information available and examine techniques that are consistent within each level or category.

The SSC is currently looking at these categories purely analytically in terms of derivation of an ABC. This is the first category. In another category, there is enough information about uncertainty in the assessment, but expert judgment is required on what the OFL, FMSY or proxy should be. If that judgment is not made through the assessment process, that judgment can be made by the SSC, and that's the third category, in terms of setting an OFL and the coefficient of variations around that OFL. Finally, there are stocks that only have catch information which is used to set ABCs.

MAFMC representatives Michael Frisk and Michael Wilberg

In brief, Categories 1 to 3 are formulaic. Category 4 is ad hoc.

There are seven stocks in Category 3 now that the SSC is using expert judgment. The OFL is output from the assessment, but the SSC is using expert judgment on the uncertainty associated with the OFL. There are five stocks in Category 4, which just are based solely on catch data.

The risk applied in the formulaic approach is based on the ratio of current stock biomass to BMSY, which is the Council's risk policy.

For atypical species, certain aspects of the life history of the species are not accounted for in the assessment. This may make that species

more vulnerable to over-exploitation and/or increases scientific uncertainty. In these cases, the SSC deducts another five percent at the full biomass level for that species.

The Mid-Atlantic Council SSC is also looking at this issue in terms of forage species and species that are becoming increasingly vulnerable to climate change, such as sedentary species (e.g., surf clams and ocean quahogs) that cannot migrate north as the sea warms. The SSC is evaluating risk policy now in terms of modifying it to account for those species.

The SSC is using an ABC based on catch levels during the period of apparent stock stability or growth for our five Category 4 stocks where there is only catch data available. However, one of these stocks, the black sea bass, has been very problematic and will be discussed later.

Some of the catch levels that are being used now were in place before the Reauthorization of the Magnuson Act. They were working for the fishery and the fishery has been stable. The industry is not complaining about not having enough to catch. Everything seems to be functioning properly.

In terms of state/federal coordination, the Council twice a year has a joint meeting with the Atlantic States Marine Fisheries Commission. In August they look at the assessment advice and ABC recommendations for the coming year. Then they come back again in a joint meeting in December to actually set the regulations for the following fishing year.

The SSC also invites the ASMC Technical Committee members to the SSC meetings when bluefish, black sea bass, scup or any other species that are also co-managed in the state waters are on the agenda. The Technical Committee members are helping the SSC with Category 4 catch-only species, looking at methods other than just average catch, such as DBSRAs or other methods that might be appropriate. This would enable the SSC to apply a more consistent approach to how to deal with catch-only species.

NEW ENGLAND FISHERY MANAGEMENT COUNCIL

When it comes to ABC control rules the New England SSC does not have an over-arching framework, and this will be discussed later. Data-poor stocks are much less of an issue in New England, but data-resistant stocks are becoming an increasingly common problem.

One of the data poor stocks is the deep sea Atlantic red crab fishery, which is a fairly small fishery. The data for the fishery consists primarily of a time series for landings. It has been supplemented by two fishery-independent trap surveys spaced about 30 years apart. This has permitted the application of a Depletion Corrected Average Catch Analysis. The two surveys showed very little change from the first to the second. The first preceded the development of the fishery and the second was after it had been developed.

The DCAC output was basically average catch, and that became the ABC with no additional buffer. However, with DCAC it was likely to be higher so that it was assumed there was a built-in buffer. It seems to be a fishery that is working well.

The other data-poor fishery is the skate complex. Similarly, the data for this fishery consists primarily of the catch time series and a survey time series. Unlike red crab, there is more reliance on the survey day than the catch data. The assessment is index-based for the seven species within the complex, and the ABC is set based on an exploitation rate estimated as the median catch-to-biomass ratio that is then applied to the three-year moving average of survey biomass.

Even though all species are assessed individually and have different index-based biomass targets, the ABC is set for the complex as a whole, and that has to do with some of the logistics of managing and monitoring the catch of individual species.

The first example of a data resistant stock is the Atlantic herring which is a data rich stock. The first ABC was set in 2009. The SSC was working with an assessment that had considerable retrospective pattern when running the diagnostics. This retrospective bias is probably the most consistent and frequent type of model resistance. It is not the only one, but it is pervasive. For these reasons, the SSC felt confident in the status of the stock, but not confident enough in the model to base the ABC on its outputs. So instead, the SSC used average catch as a basis for the ABC.

Between 2009 and 2012, a new benchmark assessment was conducted. It used the consumption data from a whole suite of predators sampled during the trawl survey to basically fine tune the natural mortality estimate within the assessment. It allowed natural mortality to vary in a way that loosely tracked the consumption data. That, among other fixes seemed to really reduce the retrospective bias and led the SSC to return to a model-based ABC in 2012.

An update of the Atlantic herring assessment is due this year, again, based on the last benchmark. But some of the preliminary work is suggesting that despite this fix the retrospective bias has returned. Although no final decisions have been made, the SSC may return to some form of a catch-based ABC. So this is a stock where we seem to be falling into a pattern of going back and forth between a model-based and a catch-based ABC, which might have some implications we want to think through.

Another particularly model-resistant stock is Georges Bank yellow flounder. Analyses show that the fishing mortality fishing mortality and biomass vary approximately threefold and fivefold respectively when earlier terminal years of the assessment are assumed. This has led to concerns about how much confidence the SSC can have in the outcomes of this model.

Further, the Georges Bank yellowtail data was made available to assessment teams from around the world and invited them to apply their own models. The SSC compared and contrasted the outcomes, which were extremely diverse. As such there is not only retrospective bias in the model but there are considerable differences between model outputs, depending upon some of the decisions made.

In recent years the catch has been markedly reduced both on the US, and particularly the Canadian side of Georges Bank. On the Canadian side of the Bank, this is a bycatch fishery. There's not much of a targeted fishery for yellowtail. So that change in Canada and increasing reductions in catch limits in the US have really reduced catch of the species.

NEFMC members Jacob Kritzer and Patrick Sullivan

However surveys conducted by both the US NMFS and Canadian DFO show that the biomass continues to decrease, and appears unresponsive to reductions in catch.

A few years ago the DFO came up with large volumes of yellowtail from two tows in two consecutive years that have not really been well explained. Some think it was just stumbling upon aggregations of yellowtail that have clustered together. Even if it was a real stock increase, what happened afterwards is, therefore, even more distressing, in that the population has been reduced considerably. So in addition to some of the model diagnostics, there is too little response to this decreasing catch.

This led to the NMFS NE Fisheries Science Center to organize a diagnostic benchmark. This was a unique process, something that had not been tried before, where the data were examined with more scrutiny that went well beyond the data that are typically used in stock assessments.

That process had four main findings:

One is that natural mortality is likely to be higher than what has been assumed, and this is not a recent phenomenon. There has been a regime shift that has caused natural mortality to increase. In short, the assessments had been underestimating natural mortality.

On top of that, there have been more recent decreases in both body condition and resultant fecundity, which seems to be then resulting in a low and decreasing larval index. This means that productivity of the stock is today lower than it has been in the past and the SSC needs to figure out how to respond to that.

The way the SSC responded in the near-term in terms of ABC setting was basically to return to an index-based approach, where the SSC set a target exploitation rate of 16 percent and apply that to the survey biomass.

NMFS STOCK ASSESSMENT PRIORITIZATION TOOL

There are a lot of reasons to consider when updating a stock assessment.

Is it because there is some change in the status of the stock?

Is there some new information that could resolve an old question?

Is there a high demand for the maximum possible Annual Catch Limit that leads to constant re-tuning of the assessment to get it to as up-to-date as possible?

Or is it simply a stock that has never been able to assess or hardly been able to assess, and there's just some lingering concern that perhaps it is a stock that is sustaining more fishing mortality than it can bear?

Thinking through the next steps is the kind of tradeoffs that need to be made. An example is trying to get the best assessments for really high-profile stocks versus a baseline monitoring for all of the stocks.

NMFS representative Richard Methot

There are a lot of tradeoffs in thinking about what's the right mix of assessments. This prioritization process is to provide a little bit of regularity to our thinking about how to go through this.

NMFS is not trying to create a strongly-proscriptive list of which stocks need to be assessed next year. NMFS is trying to guide the process, i.e. which assessments really need conducting and which can be conducted later.

Following reviews by the CCC, SSCs and the Science Board, the process has been re-invigorated and working towards pilot implementation.

The Office of Management and Budget attached it to the NMFS budget, saying that a prioritization process needed to be established. It was strongly endorsed by a GAO Review of assessments this past year. It showed up in some of the proposed language for the Magnuson Reauthorization, an approach to prioritization. It was pretty similar to what NMFS was proposing. So a lot of things are moving in this direction. There was general support for the idea of updates should be the norm. Benchmarks are not better than stock assessments.

Updates are better than benchmarks because they're building upon something that has already been established.

Conducting a benchmark should be undertaken when it is known that improvements can be made. Try to be more strategic on when conducting those full investigations.

Using fishery value in trying to look at what is the importance of stocks.

The whole concept of tiering, how to apply the most data-rich and most intensive methods for the most important stocks which are most in need and the stocks that could most benefit from it, and having less intensive methods, more data-limited methods apply in other circumstances.

There were a lot of other comments that were received by NMFS, about 60 comments in total that are being used to update the document. NMFS is trying to be as mindful as possible with the kind of concerns that were raised when the document was put out for comment in 2014.

The kind of data that to include, the kind of things that are being examined to put into a data system so that these can be brought back to each of the regional processes that go through this prioritization. As such, NMFS will work on quantifying measures of fishery importance, ecosystem importance, other regional information on high-profile stocks, and what makes them high profile.

Stock biology is important to drive the degree of the target update frequency so that we're not trying to update something that lives 150 years. Assessment updates are not needed every year for a stock with substantial longevity. Circumstances for a stock of this kind cannot change that fast, and this needs to be built into expectations for assessments.

What NMFS is looking to achieve is facilitation and some standardization of each regional prioritization process. NMFS is going to facilitate this nationally and implement it regionally. The portfolio of assessment needs will then be pretty transparent to all participants in the assessment process. Nationally, NMFS will get a better quantitative sense, of where are the real gaps in capability.

NMFS can then use that as information on where does future investments are needed in order to get the best value for investment.

Important assessments will be conducted at the appropriate times. It builds in this idea that the longer wait time, the higher the stock goes up in priority to get re-assessed. That becomes part of the cycling through of assessments, so that things that are really important will come up frequently because they have a high target frequency of getting updated. So they will quickly get past that target frequency when they get up in the priority list.

Hopefully, by this right-sizing of the assessment portfolio NMFS will be able to distribute some of the assessment effort across the full range of stocks, for which we have some information and for which we can get at least a data-limited assessment undertaken.

Questions and Answers to the Round Robin Presenters

The initial discussion focused on the Tier system used by different regions and the degree of gap between the Tier 1, data rich robust model stocks, and the stocks in the lower Tiers. Several SSCs are continuing to look at re-evaluating and restructuring their ABC control rules.

Dr. Sam Pooley, former director of the Pacific Island Fisheries Science Center, facilitated deliberations.

This was followed by discussion on the National Academy Review of stock rebuilding plans. One of the recommendations emerging from that review was that management should be based more on fishing mortality (F) than biomass, as robust biomass (B) estimates are often hard to obtain. However, the Magnuson Act requires management of stocks relative to the B and F values associated with MSY. But there seemed to be some consensus that fishing mortality reference points are more robust than biomass based reference points in terms of offering management advice.

Discussion then turned to the inclusion of environmental variability into stock assessment. Reference was made to the Atlantic herring and Georges Bank yellowtail. It was thought that both species are subject to natural variability on long-term cycles for reasons that were poorly understood. Were these environmental cycles part of the assessment models? As such the answer was no, although the consumption data referred to for the herring assessment to estimate natural mortality may be capturing such cycles.

It was noted that there was always a propensity to look for the reason an assessment is not performing well according to the model diagnostics. Several hypotheses have been advanced for the model failures for the herring and yellowtail but none withstood the test of time.

Reference was made to the Southern New England-Mid Atlantic yellowtail, where poor recruitment was observed over two decades, so this led to a change in the reference points. This was technically a success since the stock was no longer overfished but from a fishery perspective it was unsuccessful because the catches were now so low.

There were more comments on F-based and biomass-based rebuilding targets, with the NRC report being critical of biomass-based targets and for Councils to move to rebuilding approaches that are F-based. However, it is difficult to move entirely away from biomass-based approaches due to the language in the MSA. Further, in-season adjustments are not viable with F-based targets. In-season management essentially means modifying catches.

There is a long history of effort-based measures not being effective. People are smart and know how to catch fish. Thus, there needs to be separation of biomass-basis for rebuilding targets versus F-based approach for optimal management. In the US management works towards setting fishing limits that are below the limit, and less emphasis on maintaining the stock at any particular biomass levels. Whereas, in other countries, there is a stronger expectation that biomass be maintained at BMSY. This is not the same as the intentions of the Magnuson Act. The MSA is really about preventing overfishing and recognizing that biomass will fluctuate.

Having a biomass target is also a useful thing to have. But there's not sufficient recognition that those targets are not necessarily stable. There is an assumption that MSY derives from an equilibrium theorem. There appears to be plenty of evidence that these are not stable and, yet, for example, countries such as Australia treat them as fixed.

The discussion then turned to the issue of standardization, using as an example the standard operating procedure for using acoustics on the Great Lakes. One of the main motivations was to allow different lakes to be compared in terms of their outputs, the quality of the stocks, and management measures. However, what is repeatedly encountered is that different regions have different needs and different species have different productivities.. As such, was there really a need for standardizing assessments more broadly? Maybe this still applies to data collection but not to assessments. Further, there appeared to be a trend with people applying assessments in a 'black box' approach without really understanding the inner workings of the models.

There was discussion of an 'über' stock assessment model that embodied many of the points in the discussion. Some participants thought that this was possible while others remained skeptical of such an approach. Further, 'über' models can become so complex that it is difficult to apply in simple situations. There was no ready consensus on modeling approaches.

The discussion turned to model resistant stocks. Another way to think of this is that it is not the stock that is problematic, but that that stock assessment scientists are not good at conceptualizing and modeling the stock dynamics. It was suggested that model resistant stocks should not be lumped in with data poor stocks, since there may a great deal of information available but poor understanding of the stock dynamics. There should be a separate category for these stocks in the ABC control rule.

It was suggested that taking more of an ensemble approach should be adopted to bringing models forward and developing advice. However, there needs to be more deliberation about what suite of models needs to be brought forward.

A great deal of the diversity experienced in modeling is random variation on a theme of how we structure selectivity in age-based models. This is a distraction and is not moving the science forward. Consequently, a more deliberative approach is needed about what sets of model classes to use. Is there a need to have some highly spatially-structured, and others not? Are there some highly time series-oriented and others that are much more strongly mechanistically oriented?

How the assessment process is approached was an issue that NMFS was going to bring to the SSCs for further discussion.

Another perspective was offered on model resistant stocks. Model-resistant stocks have poor predictive performance and often fail because of erroneous model assumptions. The best way to diagnose a false assumption is to have a model where assumptions can be turned on and off or systematically violated.

There was discussion about the great variability of stocks, data quality, and modeling approaches; while at the same time there is a desire to standardize to the extent possible. The example of the greater amberjack was cited again as a species where data was not limited but the stock assessment model was unsuccessful. There was an enormous amount of uncertainty because there's a lot known about the biology of the species that is not captured by the existing data streams.

The question was posed how to handle the Gulf, South Atlantic, and the Caribbean where there are a very large number of stocks that will never be properly assessed with robust stock assessment models. It was unrealistic to think that many of these species will ever be elevated to higher tiers.

This brought the discussion back to the NMFS stock assessment prioritization scheme. In the case of data-moderate stocks it may be necessary to do a cost-benefit type analysis. It might not be worth the energy or resources to do a full assessment. It may be more appropriate to conduct a data-limited type assessment on those stocks.

It was noted that there has been substantial progress on the low-end data-poor approaches, and people are beginning to learn how to deal with these stocks. However, there seems to be a middle category between low end and high-end stocks -- stocks where there might be some data available for an assessment, but not enough to conduct a full assessment. Examples were provided from the West Coast, but these had not been entirely successful. However, these types of middle-level stocks may benefit from increased focus in the future.

Discussion Summary on Subtheme 1.a: Specifying Acceptable Biological Catch for Data-Limited and Model-Resistant Stocks

A tiered system of rules and criteria provides the basis for setting overfishing limits (OFL) and acceptable biological catches (ABCs) in data-poor situations (Tiers 4-6) and data-rich situations (Tiers 1-3). Both situations have their own issues with which the respective Regions must deal.

The Caribbean and Western Pacific Regions are data-poor, while the South Atlantic and Gulf of Mexico Regions are considered data-moderate. To improve these situations, regions must invest in resources to enhance their ability to collect fishery-dependent and fishery-independent information and/or better analyze existing information to generate assessments. However, changing one's data situation, although better informed, may not necessarily reduce the uncertainties and risks in the ABC specification. Each tier has different associated risks, which should be clearly communicated to the Council prior to decision-making. Shifting to a higher tier may not lessen the overall uncertainties in setting ABC and OFL. Regardless of the data situation, ad hoc decisions are still required.

Because different stocks have a different quantity and quality of scientific information associated with them, examining stock-based approaches rather than striving for uniform assessments may be advisable. Additionally, in data limited situations, other approaches to manage the stock besides catch limits should be considered, such as spatial management, effort controls, and gear restrictions to potentially reduce the risk of over fishing.

The New England, Mid-Atlantic, Pacific, and North Pacific Regions are considered data-rich, but models do not always fit the data as expected or converge or fit as well as the modeler hopes. One participant called the problem "model-resistant." Other reasons for model lack of fit could be model-misspecification or uninformative data inputs. This problem is more prevalent in New England. "Model resistance" is a new concept and could be related to lack of information on the long-term population dynamics and associated variability or to the information in the data being poor or due to a number of assumptions being violated or assumptions that are inappropriate. A broader, overarching issue surrounding "model resistance" is the unpredictability of climate change effects on the population dynamics of the stocks being managed.

The role of the SSC is to identify risk and provide the Council with scientific advice regarding potential impacts of the various risk levels on the stock. The Council's responsibility is to manage for risk, but often the tools with which to accomplish this are not made available. The Council can help the SSC develop the risk assessment framework by providing it with the components the Council needs to make its decisions. Some regions have a strong policy framework to characterize uncertainties and risks, but lack the science to feed into that policy. In the North Pacific the SSC often adjusts ABCs and OFLs for data limited stocks in recognition of uncertainty not explicitly incorporated in the assessment.

One obvious gap is the limited socioeconomic information needed to understand the cost associated with risk. National Standard 1 focuses on preventing or ending overfishing, and economic yield and fishery profitability are often not fully considered. The cost should be balanced among: 1) maintaining and improving the yields; 2) maximizing the profitability of the fisheries being managed; and 3) improving the scientific information needed to minimize the losses associated with poor or ill-informed decision-making.

Findings and Recommendations

- Invest resources (funding and man-power) to improve the ability of regions with a significant number of data-poor stocks to collect pertinent data, and in regions with numerous data sources to produce and review products to comply with the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requirements in specifying ABCs.
- Invest resources to explore different approaches for assessing data-poor stocks, then develop and implement management alternatives that allow the use of best available science that is not based on maximum sustainable yield (MSY) and reference point systems.
- Invest resources to explore different approaches for assessing stocks with different data informing their abundance and dynamics.
- Identify additional methods to evaluate risks of data limited assessments provided to Councils for decision-making.
- Enhance the communication of risks associated with shifting tiers to Councils and stakeholders so they do not confuse the detailed quantitative nature of the lower tiers (stocks with assessments and well quantified risks) with increased rigor or performance.
- Use the stock prioritization process to identify stocks that are data poor, model-challenged, and vulnerable to overfishing and invest resources to improve the data and analysis for these stocks.
- Provide more guidance to data-rich regions dealing with "model-resistant" stocks on when to downgrade to data-limited approaches, and on the need to document the available information not used and the risks associated with not using it.

SUBTHEME 1.b:

Implementing National Standard 2 in the Face of Uncertainty

Keynote Presentation: National Standard 2 in Determining Best Scientific Information Available

Speaker: **RICK METHOT**, NMFS—Office of Science and Technology

National Standard 2 (NS2) of the Magnuson-Stevens Act (MSA) states that "conservation and management measures shall be based upon the best scientific information available." New explicit requirements for peer reviews and for SSC recommendations were put in place in the 2006 reauthorization of the MSA. NMFS subsequently updated NS2 (Federal Register, July 2013, http://www.gpo.gov/fdsys/pkg/FR-2013-07-19/pdf/2013-17422.pdf) to provide guidance for implementing these changes. This update to the NS2 Guidelines also incorporated requirements and ideas from the Information Quality Act (June 16, 2005), the Office of Management & Budget's Peer Review Guidelines for all federal actions, and the National Research Council's report in 2004 on good practices for quality assurance. The NS2 Guidelines cover 4 key topics regarding quality assurance:

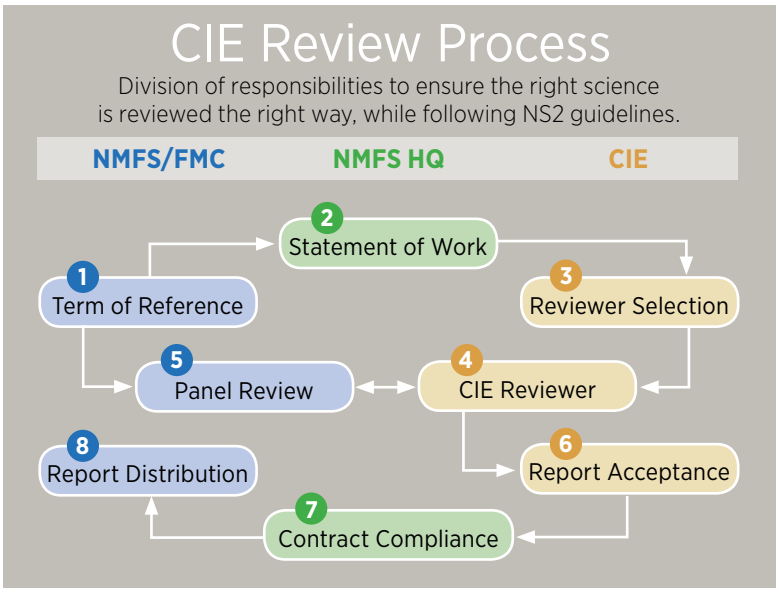
Rick Methot

- Description of Best Scientific Information Available (BSIA)
- Scientific peer review standards
- Role of Science and Statistical Committees (SSCs) in the review of scientific information
- Purpose, contents, and availability of Stock Assessment and Fishery Evaluation (SAFE) reports.

Subsequent to publishing the NS2 Guidelines, NMFS initiated an effort to assure that each NMFS Science Center—Regional Fishery Management Council pair has a peer review process that follows the updated NS2 Guidelines. Peer review processes such as the SAW/SARC in the Northeast, SEDAR in the Southeast, STAR on the Pacific coast, SSCs and Plan Teams in the North Pacific, WPSAR in the Pacific Islands are already in place to provide quality assurance for stock assessments. Although these processes have the same intent as the NS2 Guidelines, there may have been some aspects that diverged from the guidance. The effort by NMFS provided an opportunity for the Science Centers and Councils to review, tweak, document and affirm that their peer review process meets the expectations of the NS2 Guidelines. A Federal Register notice will document the results.

While it is important to have in place a process to determine that the BSIA is being used, it also is necessary to document this finding adequately as federal regulations are promulgated. This involves NMFS Science Centers, NMFS Regional Offices, Councils, and Council SSCs acting in a coordinated manner to conduct assessments, review these assessments, make status determinations, make fishing level recommendations (e.g. Acceptable Biological Catch), develop

management recommendations (Annual Catch Limits and associated Accountability Measures and fishery controls), affirm that the BSIA has been used in arriving at these recommendations, and document all for the public record. A description of the steps involved is under development and SSC input to this description will be sought. The capability of the NMFS Species Information System has been enhanced to store uploaded assessment documents, SSC minutes and other memos and reports needed to document the process.



SOURCE: NOAA FISHERIES

Many challenges to the determination of BSIA remain. One is in data-limited situations where clear-cut scientific advice is difficult to derive from available information. While various methods involving catch time series and/or life history information have been developed, all such methods place great reliance on various proxies and information derived from expert opinion rather than measurable quantities. In such situations, it is not feasible to quantify well the degree of uncertainty; consequently the appropriate degree of precautionary buffer remains difficult to determine. Which of these data-limited stocks are at risk of overfishing and hence in need of more complete assessments is a key step in efforts to prioritize assessment research and data collection.

Another challenge occurs even in the most data-rich situations where alternative hypotheses regarding stock productivity, reliability of data sources, model configurations and other factors leads to an ensemble of results. Traditionally, fishery scientists have tended towards using this diversity of possibilities as sensitivity analyses that characterize the degree of structural uncertainty in the assessment result and the management advice is derived from a model configuration determined by the review process to represent the "base case" or "best" configuration. Sometimes, a subset of alternatives are used in a decision analysis framework to evaluate trade-offs among various possible management options. Even here, it is not uncommon for there to be one model run, with all its associated technical outputs, that characterizes the final management determination. Protocols are vague or nonexistent in fisheries to arrive at a conclusion that an ensemble of results collectively represents the BSIA and that management can be based on this ensemble without needing to have a single best-case result. Protocols will need to be carefully crafted so they still meet the MSA requirement that the Council cannot set the ACL above the ABC determined by the SSC.

Discussion Summary on Subtheme 1.b: Implementing National Standard 2 in the Face of Uncertainty

Each region has a system in place to review assessments and other scientific information that the SSC uses to advise the Council on fishery management decisions. Some are independent panel reviews, such as the Center of Independent Experts (CIE), and others include the SSC and Plan Team. Several issues were raised during this session: 1) conflicting opinion on best scientific information available; 2) timeliness, transparency, and throughput of the reviews; 3) the inability of the best available science in some regions to generate the information required by the MSA; and 4) lags in the review process that results in the SSC making recommendations on ABCs based on incompletely reviewed information.

The SSC's role in the review process is critical. Some regions assign SSC members to chair the review panel. This, however, is not the case if the review is through the CIE (with exemption in some regions where the CIE review panel is chaired by an SSC member). In some regions, when the CIE or panel review results and the SSC's perspectives do not conform, the SSC must provide justification for the disagreement. It was noted that the review panel and the SSC approach the assessment from different perspectives. Panel reviewers (depending on the terms-of-reference) typically comment on the technical aspects of the assessment while the SSC also addresses locally grounded specifics of the fishery provided by stakeholders. When reviews conflict, one opinion must take precedence. It was suggested to clearly separate ideas from actual flaws in the method, model, or data. Ultimately, the SSC must make an ABC recommendation and the SSC will have a final say in which advice to use for setting ABCs.

The management timeframe that requires reviewed assessments/scientific information is typically shorter than the generation of assessments and their succeeding review. The SSC, more often, is put into a position where it is forced to make a determination of best available science to set the ABCs. The short-term fix is to add a disclaimer or caveat that the best available science existing at the time was used to set the ABCs. A backup or fallback process should be established so that everyone is clear on what scientific information is to be considered by the Council.

Some regions are experiencing significant delays in using the most up-to-date assessment or scientific information due to the rigorous review process where too much weight is placed on transparency to the detriment of throughput. The National SSC V viewed transparency as important; however, it thought more effort is needed to get assessments reviewed and finalized. One way is to reduce the number of benchmark assessments and increase the number of standard (operational) assessments and/or assessment updates. The National SSC V believed that Councils seem to think benchmark assessments are always the way to go. However, these assessments require more resources for the assessment group and more rigorous review, thus throughput is reduced. The Councils and stakeholders should be clearly informed about the different requirements for each type of assessment and associated review process.

Reviews are typically focused on models, assumptions, and parameterization, and not so much on the data and data sources that go into the assessments. This may also contribute to the "model-resistant" situation.

In cases where the SSC is not the peer-review body, it must work within the constraints of the existing information contained in the assessment. The SSC's involvement in the review process is critical as it increases buy-in and allows the analysis to address the concerns of both the SSC and the independent reviewers. Most of the time, independent reviewers are not familiar with the intricacies

of the data and the background on why a certain model was used. The SSC's participation allows for the reduction of that steep learning curve. The review should also focus on the technical aspect of the scientific information and not weigh in on the management application of the assessment results.

Findings and Recommendations

- Develop a process to enhance the throughput without sacrificing the transparency of the determination process for regions where information from assessments is urgently required.
- Develop procedures to deal with situations where the SSC and NMFS do not agree on the best science available.
- Revise the existing process to separate the review based on best available science and the recommendation for use of the information for management.
- Most reviews focus on the model used for stock assessments and less attention to reviewing the quality of the data that goes into the model. More attention should be given to reviewing the data collection programs so as to meet the minimum standards for a model-based stock assessment.
- The Western Pacific and Caribbean Regions face similar challenges in acquiring the best available science to manage data-limited stocks. Enhanced dialogue, communication, and exchange between these two regions is needed to address such issues as identifying an alternative management procedure (framework) to the usual MSY-based reference point procedure, which utilizes an automated annual evaluation of indicators (e.g., mean length, catch per unit effort, reported landings, fishery independent data streams) for all species, and to explore annual adjustments to a wider range of harvest control rules, e.g., seasonal closures, spatial closures, and minimum size.

SUBTHEME 2:

Evaluating Existing Acceptable Biological Catch Control Rules: Issues, Challenges and Solutions

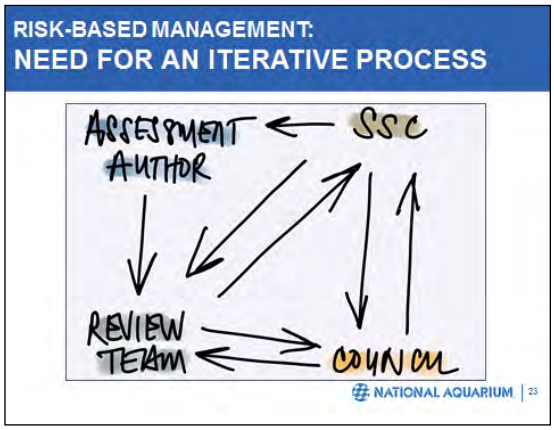
Keynote Presentation: Addressing Uncertainties in Stock Assessment in a Variable Environment

Speaker: **ERIC SCHWAAB**, National Aquarium

Eric Schwaab

This presentation will draw from *Addressing Uncertainty in Fisheries Science and Management* (2014, aqua.org/fisheries), a recently completed project undertaken to advance best practices for addressing the impact of science and management uncertainty on fisheries management systems. The project engaged a panel of experts and the work was facilitated through the examination of a series of case studies and identification of findings, recommendations and best practices. The project used structured approaches to assess how uncertainty is evaluated, reduced, and managed for in fisheries science and management.

The Panel focused on science and management approaches separately, but also probed the implications of work that takes place at the interface of these two fields. The Panel and the report included particular focus on challenges of managing fisheries in the context of environmental change. The Panel identified opportunities to expand and better integrate oceanographic and ecosystem science into single species stock assessments, and better anticipate and prepare for environmental shifts. The Panel also identified best practices ranging from the North Pacific Fisheries Management Council's Ecosystem Considerations Report to greater use of Management Strategy Evaluation as potential responses.



Facing climate change: Pacific sardine case study

CHALLENGES

- Combined stocks
- Multiple stocks with overlapping distributions
- Widely varying recruitment, in response to environmental drivers
- Lack of data from southern catches
- Environmental change uncertainty
- How to choose a management strategy?

LESSONS LEARNED

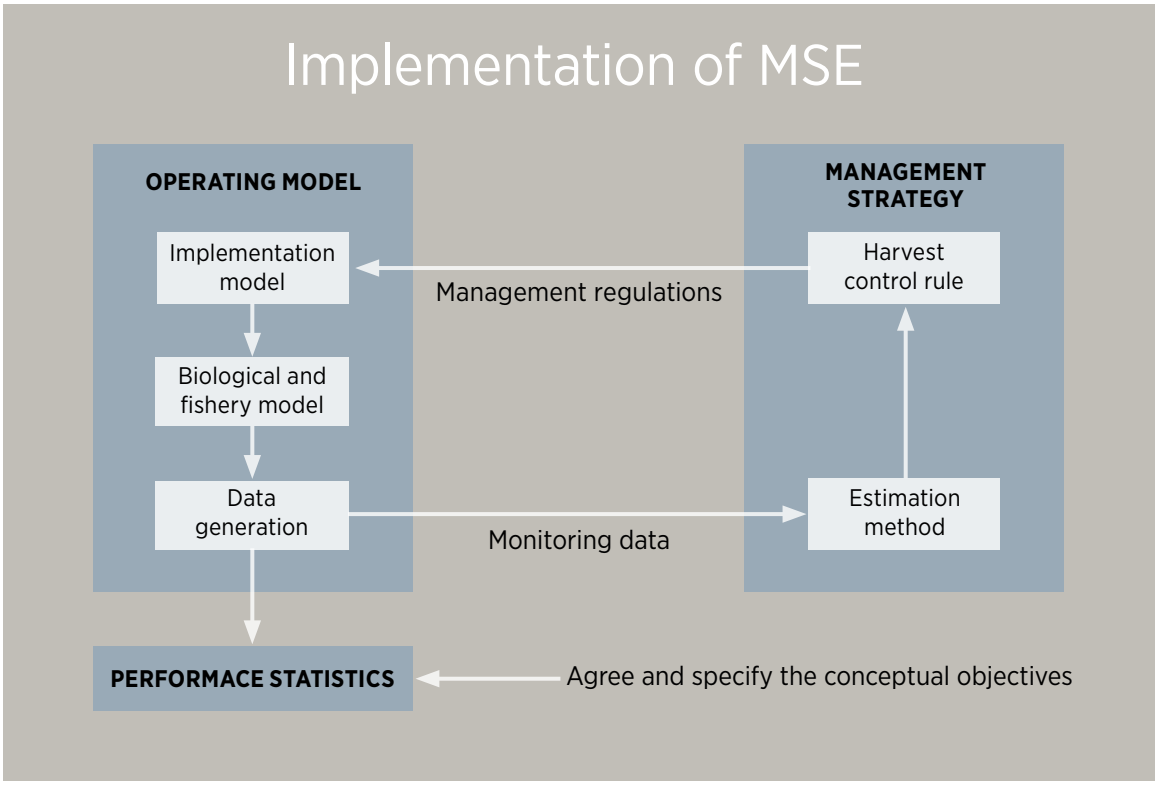
- MSE workshops improve communication about uncertainty
- MSE can reduce impacts to stakeholders, consider effects of environmental change, select preferred management option
- Harvest control rule to incorporate environmental effects

Keynote Presentation: Use of Management Strategy Evaluation to Assess Performance of Harvest Control Rules

Speaker: **ANDRÉ PUNT**, School of Aquatic and Fishery Sciences, University of Washington

André Punt

Management strategy evaluation (MSE) involves using simulation to compare the relative effectiveness for achieving management objectives of different combinations of data collection schemes, methods of analysis, and subsequent processes leading to management actions. MSE has been used to evaluate the theoretical properties of management strategies and the behavior management systems for single species and in an ecosystem context, although most implemented management strategies are single-species. However, the value of an MSE depends on the extent to which it addresses the objectives for management, and characterizes uncertainty, as well as how closely the analysts work with managers and key stakeholder groups. The results of MSE studies have used to lesser extent in US fisheries compared to those in Australia, South Africa, and Australia, even though many MSE studies have been undertaken for US fisheries and the results reported in the literature. Four case studies (generic ABC/ACL control rules for data poor species, OFL/ABC/HG control rules for the northern subpopulation of Pacific sardine, rebuilding strategies for west coast groundfish, and ABC control rule for fisheries in the North Pacific) are used to illustrate the types of situations to which MSE can be applied and highlights the lessons learnt regarding how to use MSE to evaluate management strategies for US fisheries, and the extent to which each case study applied the 'best practice guidelines' developed by Punt *et al.* [*Fish and Fisheries* in press].



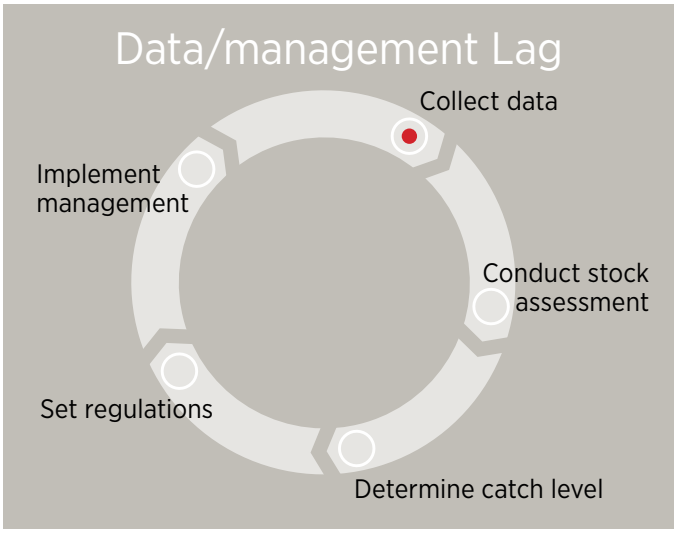
Keynote Presentation: Comparing Performance Among Alternative ABC Control Rules

Speaker: **MICHAEL WILBERG**, Center for Environmental Science, University of Maryland

Michael Wilberg

The 2006 revision of the Magnusson-Stevens Act ushered in a suite of changes for U.S. fisheries management including the use of Acceptable Biological Catch (ABC) control rules to limit harvest. Each of the eight regional fishery management councils developed their own approaches for setting ABCs, but little information was available to compare alternative methods for ABC determination. We developed a management strategy evaluation (MSE) that allows us to test the performance of alternative methods for setting ABCs. The primary objectives were to determine the effects of assessment frequency, amount of time between the last year of data included in the stock assessment and implementation of the ABC (data lag), and alternative ABC control rules on important fishery metrics such as population biomass, catch, and probability of overfishing.

Assessment frequency, data lag, data quality, and the stock's life history had important effects on control rule performance. Longer times between assessments led to lower catch, lower biomass, lower inter-annual variability in catch (AAV), and higher probability of overfishing. Generally, increased data lag tended to decrease average catch and average biomass, while increasing the probability of overfishing. The effect of data lag on AAV depended on the life history, with little effect of data lag for the slow life history and a decrease in AAV with data lag for the fast life history. On average, data lag effects were greater than those of assessment interval for biomass, catch, and AAV.



The ABC control rule scenarios included eight control rules, eight methods for setting ABCs (projected or fixed ABC, phasing in of the ABC, using alternative assumptions when doing projections), three exploitation histories, two assessment intervals, two productivity scenarios (recruitment variability and autocorrelation) and multiple levels of assessment error. Exploitation history affected control rule performance with stocks that had previously experienced overfishing doing better under the control rules than those that had a history of light fishing. State-dependent control rules resulted in similar long-term yield, but with a higher AAV and a lower probability of overfishing compared to fixed control rules. Long-term average yield was comparable across state-dependent and constant fishing mortality control rules. Increasing the assumed CV of the OFL distribution resulted in comparable catches, but with a lower probability of overfishing for both fixed and state-dependent control rules. The different methods for setting the ABC did not have a large impact on population size or average catch, but they did have an effect on the AAV of the catch, with fixed ABCs and phasing in the ABC having a lower AAV compared to runs using projections. Variability and autocorrelation in recruitment had relatively little effect on control rule performance.

Round Robin Session: Evaluation of the Current ABC Control Rules (with emphasis on how each council monitors the performance of the control rules, issues, challenges, and solutions)

NORTH PACIFIC FISHERY MANAGEMENT COUNCIL

Challenges and solutions for specifying ABC

Many challenges associated with specifying annual catch limits have been addressed throughout the history of council management. The North Pacific Council has managed groundfish stocks with annual catch limits since 1977, and has used a data availability-based tier system for OFL control rules since 1990 and ABC control rules since 1996. The process has become quite standardized and streamlined such that the SSC can annually review stock assessments and assessments updates for all stocks and stock complexes (24 in the BSAI, and 22 in the GOA). NMFS assessment scientists prepare assessments and updates using standardized content for reporting the assessment, so that all information is included and accessible. These assessments are peer reviewed by the Plan Teams and packaged into an annual SAFE report, along with detailed minutes of the Plan Team highlighting concerns and issues for authors to address in the next assessment. The Plan Teams also recommend OFL and ABC levels. The SSC reviews proposed new models, data and/or parameterizations to be used in the assessments at the June meeting (crab) or October meeting (groundfish), and provides direction to assessment authors about which models to bring forward to the October (crab) or December (groundfish) meeting. At its October (crab) or December (groundfish) meeting, the SSC reviews the assessments and updates for every stock, receives the Plan Team report and recommendations, and sets the next year's OFLs and ABCs for all of the stocks. The SSC's reviews normally take two days, and minutes are prepared during the meeting. The SSC chair then provides an oral and written report to the Council a day or so later when the Council is establishing ACLs.

One of the major challenges for the SSC is model selection. Age structured assessments contain a section in the assessment report that evaluates each model's performance. In addition, the base model used for the prior year's assessment is often compared to alternative models. Criteria used for choosing a model include: statistical performance (i.e., best fit to the data, change in likelihoods, AIC or similar statistics), biological plausibility, retrospective performance, predictive performance, incremental versus radical change, and professional judgment. The issue of choosing the appropriate model came to a head several years ago. The number of models that were included in the annual Pacific cod assessment kept increasing until the workload (both preparing the assessment and reviewing it) became unwieldy. To address this problem, the SSC developed a winnowing process that starts with suggestions from the plan team, SSC, CIE reviewers, external analysts, and model explorations by the assessment author. The plan team reviews the candidate models and recommends a suite of models. The SSC then selects the 1st set of models, and the preliminary assessment is presented to the plan team and SSC. At its October meeting, the SSC then selects the final set of models that will be presented at its December meeting.

Evaluation of ABC Control Rules

The control rules used for groundfish have been very effective at maintaining stocks at or above target biomass levels. For over 35 years, no groundfish stocks have fallen to 'overfished' levels, and there has been only one instance of a stock being subject to overfishing (and this occurred for only a single year). Should a stock decline below target levels, the control rule provides for reduced harvest rates, and thus improves the likelihood of rebuilding quickly. Phase plane diagrams that are included as part of the stock assessments provide tracking

of how the biomass and fishing mortality change over time. In most cases, stocks have increased during periods of low fishing mortality, and decreased with periods of increased fishing mortality.

Addressing Uncertainty

Communicating uncertainty is important in order for the Council, SSC, and public to understand the risks associated with management decisions, particularly when it comes to establishing ACLs. Many of the stock assessments illustrate uncertainty in the figures showing biomass and recruitment. Techniques to illustrate this uncertainty have been improving over time. Decision tables and cumulative probability distributions are useful tools for communicating uncertainty and quantifying risk into a risk assessment for decision makers. In addition, MSE is being used more frequently to periodically evaluate the performance of alternative management procedures (e.g., harvest control rules).

Uncertainty within stock assessments is being addressed in several ways. Measures of uncertainty are required for Tiers 1-3. Statistical tools used include likelihood profiles, Bayes posteriors, and variance approximations based on the inverse Hessian matrix. A simple random effects model has been used to better characterize trends in survey biomass and uncertainty for Tier 5 stocks. This model has also been used (not just in Tier 5) to partition a stock-wide ABC among separate management areas based on biomass distribution. Gmacs (Generalized Modeling for Alaska Crab Stocks) is a size-structured assessment modeling framework designed for stock assessment of hard-to-age species, and a Gmacs model has been developed for some of the BSAI crab stock assessments. Gmacs is an open source program developed in AD Model Builder, with multiple options for estimating uncertainty. Lastly, some stocks have environmentally informed assessments that incorporate environmental data into key stock parameters.

WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

Regarding the issues and challenges of monitoring the performance of control rules, much of it has to do with the fishery-dependent data collected by the State and Territories in the region. The State and Territorial agencies do not collect fishery data with science in mind. Often their objective has more to do with local socio-economic issues than fishery management. The reliability of catch, effort, and species identification is frequently suspect.

As a consequence things like species are not well identified. Often effort statistics are either grossly defined or not included at all. This severely limits the ability of the Western Pacific Region's SSC to calculate reliable estimates of ABC.

The biological data is limited given the vast array of tropical species for which the SSC has responsibility. The SSC struggles with understanding the state of the species that are being targeted, let alone those that are not being targeted.

Economic and social information used to qualify the estimation of control rules is also pretty limited.

The only fishery-independent data the SSC uses are coastal reef fish surveys, which have been used in a number of cases.

The SSC is forced to use species assemblages to define ABCs, even though they are well aware of the problems associated with such groupings.

An unanticipated event was the magnitudes of change in the maximum age of target bottomfish species. The SSC was however surprised by the impact of that metric on the stock assessments and therefore the ABCs.

Another difficulty is that people like to keep their fishing locations secret. The ability to collect location information is very difficult, and it does impact our ability to model the dynamics of our fisheries.

Another problem that the SSC has encountered is that within the Main Hawaiian Islands deep-water bottom fishery there are just a handful of highliners who provide the majority of the catch in the fishery. When one or more highliners exits the fishery it compromises assessments.

With respect to non-commercial catches the SSC has examined the data generated by the national Marine Recreational Information Program (MRIP) but is unsure of the scale of that non-commercial catch compared to the commercial or the artisanal catches. So the stock assessments have, by and large, not accounted for non-commercial/artisanal catch and effort. The SSC is very aware that this is not a good situation.

With respect to evaluation and monitoring the SSC is mostly limited to reviewing ACLs compared with recorded or estimated annual catches on a post hoc basis. The SSC does not conduct any model-based MSE type analysis, and would need technical assistance to do so.

As far as improvements are concerned, one of the SSC's questions is, would it really be worth the cost of trying to improve western Pacific catch data for all of these artisanal/recreational fisheries? It would be very expensive and very difficult to do so.

The SSC would like to explore other ways of trying to deal with Pacific island reef and bottomfish resources. Setting ABCs for individual reef fish stocks is unfeasible, given the data and resources available. In a number of cases the SSC has had to use proxies to arrive at some estimate of ABC in time to meet official deadlines.

One of the things the SSC has discussed is trying to use some ecological, ecosystem-type tools in order to see whether fishers are having major impacts on some communities, primarily the coral reef community. Proceeding on that basis might be more efficient than attempting to look at individual species.

The SSC would like in many cases to move back to the use of size composition and sexual maturity. These data streams were abandoned when the SSC started specifying formal OFL definitions and ABCs. The SSC thinks this may be a way to avoid working with many of these species assemblages.

PACIFIC FISHERY MANAGEMENT COUNCIL

The Pacific Council salmon and highly migratory species FMPs both have international exceptions. The new framework has been very challenging for salmon which have a very complex management system, with four states and many tribes. They're also managed under the Pacific Salmon Treaty and have a unique life history.

Many of the Pacific salmon stocks are ESA-listed. They are comprised of hatchery fisheries. Also, the environment has a big role in their productivity and abundance. Only have two stocks are given ACLs and they have a simple ABC control rule. There are two tiers for salmon. The Tier-1 category has data on the spawning recruit relationship. If they have stock-specific information and can come up with an FMSY times 0.95, this gives them the FABC.

In Tier 2, if there is no stock-specific data or information, then an FMSY proxy is used to generate the ABC. The ABC is represented as catch as the FABC times the preseason forecast. A lot of salmon folks work on the forecast, because that's what really drives the annual harvest in a given year.

For highly migratory species, since they do not have to have ACLs, there is no specified ABC control rule. However, these species do have status determination criteria and MSYs are specified for highly migratory species. Further, the tuna RFMOs are developing some reference points for tuna stocks. The Pacific Council has adopted a limit reference point for albacore.

With respect to groundfish, the Pacific Council SSC document uncertainties, phase plots and tracking the targets in our stock assessments. The Council puts everything in the SAFE documents and also in the EIS.

This past year there was also an evaluation of the California Current Ecosystem for the Tier 1 EIS. This looked at the ecosystem impacts of groundfish harvest over a wide range of catch levels. This was an interesting exercise that contributed to looking at the ecosystem, along with groundfish harvest.

The SSC also evaluate catches relative to ABCs, as far as a monitoring step. Pacific Council managed stocks appear to be staying under our ABCs and no overfishing appears to be occurring.

There have been some improvements to the SSC ABC control rules through a workshop process following the stock assessments. The first looked at the control rules relative to B0 or the biomass with zero fishing. The SSC would like to examine alternative control rules through the MSE process.

The second is the productivity workshop. This has changed over time, but initially developed to look at how productivity is modeled in our data-moderate assessments, compared to our data-rich assessments. XDBSRA, which is one of the methods we use for our data-moderate assessments, it's extended DBSRA in the sense that it has an index along with the catches, unlike DBSRA, which just uses catches.

That productivity is modeled differently. It is more flexible than stock synthesis, which is more constraining, because it's based on just the Beverton-Holt stock recruitment relationship. The SSC would like to just compare and evaluate those two different ways of modeling productivity, which may influence our sigma estimates in the long run.

These are some current MSE work with the North Pacific Groundfish ABC Control Rule and the Rebuilding Revision Rules. Then SSC would like to conduct more work on re-evaluating sigma, including more of the uncertainty more than the biomass. The SSC would like to look more into the uncertainty of FMSY and also forecasting.

The SSC would like to do more work on data-moderate and data-poor species. Additionally, there are methods being investigated for decreasing uncertainty, and the indices used in Pacific Council assessments. The SSC is reviewing work using geo-statistical Delta GLMMs, with the hope that this decreases uncertainty in the indices, and hopefully that decreases the uncertainty in the assessment and sigma.

GULF OF MEXICO FISHERY MANAGEMENT COUNCIL

The Gulf Council's ABC control rule has three tiers, data-rich, data-moderate and two sub-tiers under data-limited.

In data-rich assessments, there is a quantitative assessment, which provides an estimate of OFL based on MSY or its proxy. A PDF of OFLs is computed that reflect scientific uncertainty. Then the SSC uses P-Star algorithm. The Council's risk policy is that there should between a 30 and 50 percent range of probability for overfishing.

Typically, the P-Stars are between about 0.38 and 0.42. For the data-limited stocks the SSC use mean of a landing series. It differs between landing series for which the SSC perceives biomass to have been stable or increasing; versus stocks where we believe that the recent catch has been unsustainable.

The SSC is beginning to explore data-limited assessment methodologies, but that has not been conducted extensively to this point.

What are the implications or concerns with respect to how this has been done in the Gulf?

First the top tier, data-rich assessments typically produce leptokurtic PDFs, which means very narrow and tall PDFs. Even if there is a low P-Star the net result is a small buffer between OFL and ABC if the control rule is applied as written.

The SSC has periodically departed in an ad hoc manner from the control rule. While this is unsettling, the SSC has invoked the vague expert opinion that the PDF doesn't fully capture scientific uncertainty. The SSC has an ABC working group, and an ABC control rule

working group, that is working with scientists from the Southeast Fisheries Science Center and other personnel to explore this in more detail.

The SSC has taken two approaches when deviating from the default ABC control rule. The first is simply to co-opt the sigma that came from the Ralston, et al., 2011 meta-analysis for the Pacific stocks, and show the Council what the implications of that would be for generating PDFs. The SSC has discussed the possibility of conducting a similar meta-analysis in the Southeast. But there are a couple of factors that have precluded that from occurring to this point, one of which is simply manpower and trying to get Center staff time to do this relative to other demands on their time.

The second issue is that unlike in the Pacific, where stock synthesis and its various iterations had been used for some period of time so that it was fairly straightforward in order to capture estimation error and model specification error, in the Gulf we have some stocks that have been transitioned even over the past decade from production models to VPA and eventually to statistical catch at age models, principally, Stock Synthesis.

But there are other examples from the region where the approach is not as straightforward. So another proposal is simply the setting of the ABC as the yield at 75 percent of the FOFL, which is FMSY, or its proxy.

Council staff is developing this as an options paper that will be presented to Council with some more analysis performed by the Center.

Moving forward, the SSC hopes in the near future to have a meta-analysis of this performed and, again, similar to the Ralston et al. 2011 approach but with some nuances relative to the Gulf Region.

Another issue is that the SSC has not encountered assessments which would be evaluated under Tier 2. This probably results in the SSC not exploring data-limited methodologies as extensively as some other regions. Therefore, the SSC may end up with more data-moderate approaches through such exploration.

There is a strong consensus within the SSC that the current method for assigning ABC, hence ACL, really, for data-limited stocks is a poor approach. The SSC is pursuing data-limited methodologies, but that it does not appear on the assessment schedule until 2016.

Lastly, unexpected sources of variance provide challenges in the Gulf Region to fully capturing scientific uncertainty and applying the ABC control rule even for data-rich stocks.

In 2010, the Deepwater Horizon oil spill occurred. There have been multiple ecosystem impacts from this disaster including include genomic effects, disease and lesions. Recruitment declines have been documented in some species. There have been food web impacts and fish community structure shifts, and also declines in size-at-age.

A benchmark red snapper assessment was conducted in 2013. However, data from 2010 Deepwater Horizon oil spill was not fully available of the model. Over time the management of red snapper has been successful and the spawning stock biomass of this overfished stock has started to recover. This has resulted in recruitment upticks, both in the west and the east components of the stock. More recently in 2008, low recruitment occurred in both regions that have persisted. Whether this is related to the spill or not has not been determined.

Another source of uncertainty is the steepness parameter "h" in the stock recruitment relationship. This is often fixed which has implications for MSY. As a consequence, instead of using the MSY estimate that comes from the assessment, the SSC uses a spawning potential ratio proxy. Instead of using the stock recruitment relationship to project future recruitment, the SSC take an average of recent recruitment and projects that forward. The SSC would never recommend using this approach to determine OFL or ABC for more than about three years of projections, unless the spawning stock biomass was estimated to be well above its threshold value. Projections well into the future become highly uncertain. Episodic

events such as the Deepwater Horizon oil spill, although hopefully extremely rare, obviously impart quite a bit of uncertainty in our region.

Another ecosystem impact that may have longer lasting effects than the Deepwater Horizon oil spill is the invasive lionfish. The estimated density of animals on artificial reefs is a couple of orders of magnitude higher than natural. However, as a result of the Deepwater Horizon oil spill, and the amount of effort focused on sampling the northern Gulf ecosystem, one offshoot of that was the capturing of the progression of the invasion of lionfish. The animals were seen when they first showed up, and then followed through time. This has the potential for catastrophic impacts.

The Caribbean has been dealing with this for a much longer time, even in the South Atlantic Council Region, this has been an issue. The SSC has already documented impacts to native fish, both direct and indirect. These include direct consumption by invasive lionfish, but also competitive interactions, where they're foraging on native fish that commercially and recreationally-exploited fish would otherwise consume. This is causing a change in recruitment, as well as foraging dynamics, in the system. Ongoing ecosystem modeling is attempting to characterize both the Deepwater Horizon event, as well as lionfish invasion. The University of South Florida has developed an Atlantis model for the Gulf of Mexico to model both of these issues.

Red tide is another episodic event that's becoming more frequent, whether this is related to global climate change or other factors. There was a massive red tide event in 2005, for example, on the west Florida shelf. The net result was an estimated 50 percent decline in the spawning stock biomass for gag, a large serranid in our system.

Another red tide event occurred on the west Florida shelf in 2014. The SSC used an EcoSIM model to estimate that the amount of mortality was a fraction of what it was in 2005, although this event was nearly as broad in scale as the earlier event. This is another example of an episodic mortality event that causes uncertainty, not only in estimates of stock production and stock biomass, but also in how well the SSC is able to apply an ABC control rule that doesn't explicitly account for these episodic sources of mortality.

CARIBBEAN FISHERY MANAGEMENT COUNCIL

The Caribbean Council SSC uses average catch for OFLs, which are totally unrelated to MSY, and only provides an indication of the magnitude of the fishery. There are no benchmarks from the SEDAR assessments, although these are all length-based. Although, the SSC has been able to detect, for some of the species, large, generally multi-decadal changes that are significant. However, these are also hampered by large variabilities in the basic biological parameters of the species.

The biggest problem is data quality. For Puerto Rico, for example, there are issues not only in recording what is being landed. There is also a major problem in converting this into total landings. The uncertainty associated increases as the catch is broken down by species. The conversion factors are applied to the fishery as a whole. Some sectors reliably report their catch but other sectors do not, nor their fishing locations.

In the US Virgin Islands, there was until recently, no species specific data except for conch and lobsters. Length frequency data is not collected consistently over time, or area. There are gear and area interactions.

There has just been completed a red hind assessment. The SSC observed significant differences in the mean sizes over time. But that was driven by the fact that in one area the data was coming from two different gear types. There was a difference between what the traps were catching at one point versus a change in the fishery to spear fishing. Spear fishing was targeting larger fish. What looked like a big change was due to gear selectivity.

In another area there was a big difference because the Council closed an area for spawning aggregation. Therefore, the big fish that had been available at spawning aggregation were no longer available to the fishery, and the fishermen had to fish elsewhere. This looked like a significant change in what the mortality structure, but it was really due to switching to fishing in different areas, which created a different stock structure.

The Caribbean Council and SSC really do not have good catch and effort data. As such catch and effort data has not been incorporated into management measures, and this is an area where the SSC is trying to make improvements, as well as detailing the species-specific aspects of the landings.

Then SSC does have fishery-independent data, available to it but it is limited. There is the SEAMAP Caribbean Program, which is part of the SEAMAP Program for the Gulf and South Atlantic. It provides very limited data on a limited set of species. But for those species, it can be used to confirm large trends, which was used in the red hind assessment.

There is also university-based monitoring, and this is mostly reef monitoring. It is looking at the status of coral reefs, as a whole, and fish data is collected with that.

There is an Encrypt Program that has just had its first round in Puerto Rico and St. Croix. That's a large-scale, SCUBA-based, census monitoring. But that is also targeting coral reefs, in particular. So there is a lot of effort being directed into looking at corals, and it is not specifically designed to look at the more commercially-important species. So it will be sometime before the SSC get an updated trend there to look at and see whether the data needed for the commercial species is being collected.

There are some also spawning aggregation trends, but those are depending on funding levels, which go up and down. So there's not consistent coverage.

For the evaluation of the Caribbean control rules, just as in Western Pacific, the SSC is limited to comparing catch limits to the actual catch. Overages are based on a three-year running average.

Most of the significant overages encountered have had have been due to data problems. Two examples in the USVI, now that they have just started new species-specific data, their data has improved. So the SSC is starting to see more catch being reported. It is not that fishing had increased; they are actually fishing less because of the economic situation. But because of reporting, it looks like an overage.

In Puerto Rico, there was a serious problem because the government opened up the queen snapper fishery anybody, and many recreational people decided they wanted to be commercial fishermen in name. There are benefits for that, and they allegedly falsified their reports. Some of these falsifications were extreme, and that caused a big bump up in the data. Everybody acknowledged this was the source of the problem, and Puerto Rico government was then able to put in a limited entry program for that fishery, and they reduced the fishermen numbers, but they were not able to clean the data.

There was no way of estimating how much the data was overshot. So the SSC had to treat it as real, and there was a major overage for that fishery, which is about to come out of that one-year blip. The time period since we've been conducting these evaluations is fairly short. As such, the time series isn't really long enough to evaluate what is really happening with the tools that we have available.

The period for assessing USVI, because they reset the data collection, it's basically going to be another 10 years in the future. On top of that, we are going to be adapting island-specific fishery management plans, and as part of that, the process for setting ACLs may change, which may just reset the clocks again.

SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL

The South Atlantic control rule is structured in a way that is fairly similar to what was already described for the Gulf. The SSC has not had a formal comparison, or formal performance evaluation for the assessed stocks, in terms of evaluation of the current ABC control rule.

A small working group has been established to set up some Terms of Reference and try to work with our SSC in evaluating how the SSC ABC control rule is structured, and the performance of applying an ABC control rule.

There was a workshop in the fall of 2014 but it failed to live up to expectations in terms of how to measure and how to evaluate that performance. Ideally the SSC would assess and establish the ABC based on P-Star. Then look at the landings after setting the ABC and have a follow-up assessment to see whether the probability of overfishing was really realized or how badly or how well the SSC did.

Unfortunately there have had very few stock assessments after the P-Star was set. The implementation of the SSC ABC control rule has been recent enough that there has not been enough time to have a number of consecutive assessments where the SSC can examine whether the previous recommendations were realized in reality or not.

Further, for those stocks with a P-star assessment, the Council did not set the ACL according to our ABC control rule. In this case, the Council had some special circumstances where they favored following the definition of OY, and used this instead.

So it is difficult for SSC to measure how the ACLs were implemented, versus our ABC recommendation because the Council decided to do something different. There are several stocks with these special circumstances, such as rebuilding plans that preceded this latest iteration of MSA. So there are a number of rebuilding plans in place, and the SSC has not really re-assessed those stocks in a way of seeing whether the performance of the rebuilding plan is really on track or not.

The uncertainties found in the South Atlantic that are inherent in the assessments need further elaboration. Firstly, there is the large recreational fishery which is widely distributed across the region. A fairly large proportion of landings come from the recreational sector. There is the issue of the MRIP estimates and the difficulties associated with these. The SSC knows that these are probably not being properly captured in the assessment framework.

Secondly, there are some special life histories in the South Atlantic, particularly protogynous hermaphroditism in groupers. There are large commercial and recreational grouper fisheries, but the impact of that protogyny into the dynamics of the stock has not been incorporated in the assessment. So that is another form of uncertainty that we are struggling with in terms of capturing in our assessment.

For the data poor stocks there is a great deal of reliance on expert judgment. Several unassessed stocks have enough data to support qualitative assessments. The assessment and analytical capacity in the South East Science Center has been an issue. There are stocks that have ABC catch level recommendations on data-poor methods that could have a full assessment with a more quantitative, better informed process. But unfortunately, the manpower, the analytical capacity in our center hasn't been able to handle these stocks.

About 15 stocks represent 80 percent of landings and many of those stocks have been in an overfished or overfishing state for a long, long time. So a number of them are under rebuilding plans. The ones that are not, and just had overfishing, and had to have their catch levels reduced substantially, are generating a lot of stakeholder anger. As such, there is a great deal of pressure on the Council to try to revisit the same data-rich stocks time and time again. So those are the high-end fisheries, generating most of the Council's interest. But that is leaving some of these other stocks for which there could be assessments not being subject to full stock assessments.

Another issue is workload and the assessment capacity of the Southeast Center. Although new

stock assessment scientists have been hired, there has been a bottleneck in data processing and data management which leads to assessment delays. This is something that the SSC is working with the Center with and trying to resolve.

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

The Mid Atlantic has 12 stocks that have stock assessments and ABCs. None of them appear to be in trouble at this point. The only complaints received from the fishing industry are the abundance of black sea bass and dogfish.

However, one issue that continues to vex the Mid-Atlantic SSC is ABC consistency. This has been a particularly challenging problem for data-poor stocks, or stocks for which there are no OFLs available. There are seven Category 3 stocks and five Category 4 stocks. Category 4 is the one for which the SSC does not have an acceptable assessment to derive an ABC recommendation.

Category 3 is the formulaic P-Star approach. The SSC uses a default OFL coefficient of variation (CV) of 100 percent, assuming a log normal probability distribution. This was based on a meta-analysis of stocks for which estimates of the CVs were available for fishing mortality and stock biomass -- the two components of the OFL. For summer flounder, the SSC reduced the CV somewhat to recognize how sources of uncertainty were handled in the assessment.

Category 4 methods for deriving ABCs have all been based on average catch, by using either status quo, recent landings, or a time period for which the stock was apparently stable or actually increasing in biomass.

Two problematic species the SSC has to deal with are black sea bass and Atlantic mackerel. With respect to the black sea bass, the fishing industry north of New York is complaining that there are too many of them creating some serious overages in the recreational quota. The commercial fishery has been within quota, but the recreational catches have been double or even triple the quota in recent years, causing some accountability measures to kick in. This caused the Council to go back and amend their management plan to revise the accountability measures because they were considered much too harsh for the situation.

The SSC chose an ABC for black sea bass that was the average catch during the recent stock rebuilding period, about a 10-year span. Although the catches in the northern part of the range have been very high, catches in the southern part of the range have been lower than expected. Thus, there is the question of whether there is one or more stocks of black sea bass.

Current attempts to answer this question have not yet succeeded. Further, the Council is unhappy with the SSC recommendations on black sea bass quotas. In summary, the Mid-Atlantic Council and its SSC is faced with overages and quotas and high discard levels for black sea bass.

With the Atlantic mackerel, as the assessments developed over the years the biomass level declined with increasing exploitation, but it was still pretty high. Then the stock more or less disappeared. Recruitment is still occurring in the Mid-Atlantic area, but there are essentially no adults.

The US theory, with which Canadian fisheries scientists disagree, is that the stock has moved out into the deeper water and maybe moved up the Gulf Stream; Greenland and Iceland have demonstrated increasing mackerel landings in recent years. It may be the same stock, but there is no proof that it is.

The Canadians think it's a decline in overall productivity, and the stock biomass has really dropped. The fishing industry perspective is not to write off the mackerel, because if they had moved offshore and they could move back inshore. The industry wants to maintain the quota so they can benefit from such an eventuality. Fishing vessels still search for mackerel schools, but because of fuel prices, the market, and the high probability of not finding them, they haven't been searching as hard in recent years.

This year fishery has been picking up in the mid-Atlantic so they may be moving back, those that are still out there. What the SSC set in previous years is a faith-based ABC that the stock is out there somewhere. However, the SSC keeps seeing this lack of evidence of adult biomass in the survey region. As a result, the SSC took a pretty draconian cut to the ABC this past year. This was not arbitrary, but based on expert judgment. The expert judgment says it should probably be half of what it was in the past, even though the fishery is operating at about three percent of the ABC, three to five percent in recent years. An MSE analysis is being conducted to examine the appropriate time span of years the SSC should use to develop an ABC based on average catch.

NEW ENGLAND FISHERY MANAGEMENT COUNCIL

The North Pacific Council SSC takes an FMP-by-FMP and even stock-specific approach. There is no omnibus tier system in place yet. Often, ad hoc approaches are used each time the SSC has to set an ABC. This includes changes for a given stock from one assessment iteration to the next. Typically, deviations from the default control rules are tied to some combination of stock status and/or information quality.

One advantage of this more flexible and ad hoc approach is that the SSC can be very responsive to the unique attributes of a given stock and the science underlying it, including new information and experience, both experience in the fishery and experience in the assessment and ABC-setting process.

A disadvantage is consistency, which is problematic for also industry and managers and environmental NGOs. In our region, it's not just those pesky NGOs that ask questions about consistency.

Then SSC has not yet conducted any formal and comprehensive evaluation of the Council control rules, including whether the rationale and performance is comparable or not among stocks. This is something that the SSC needs to examine.

But the SSC has created a Risk Policy Working Group. This group is trying to create a framework for both evaluating risk and determining risk tolerance. This is hopefully going to ensure we have more consistency in the rationale from stock to stock,

The most species-diverse and control rule diverse FMP in New England is for groundfish. It has these four default elements. The first is that the SSC set ABCs based on 75 percent of FMSY. It is not written in, but it is understood that that is FMSY applied to projected biomass over whatever time frame we're setting specifications for.

The next step if a stock is rebuilding the ABC will be set at 75 percent of FMSY or at Frebuild, whichever is lower. In some cases, 75 percent FMSY has been lower than the Frebuild.

The SSC have a third provision for stocks that cannot rebuild, according to the projections, even with no fishing mortality to set an ABC based on some estimate of incidental non-target bycatch with a reduction. The SSC does not want to shut down these multi-species fisheries and force a zero ABC, but to reduce from the status quo.

The fourth provision is where we have unknown status, the SSC can use its judgment and develop sort of case-by-case approaches.

These four default approaches are preceded by language that states that these are default approaches if there is no reason to do something different. But if the nature of the information before the SSC compels it to better specify uncertainty and better determine an approach for setting a control rule, then the SSC has that flexibility.

After the act was reauthorized when this control rule was first written and approved, all of the ABCs for the 20 groundfish stocks were set by one of these four methods. Over time, though, there has been some evolution for stocks, which will be illustrated by three examples given here, namely, Georges Bank haddock, Georges Bank cod and Georges Bank yellowtail flounder.

The haddock is one of the SSC and Council success stories. Biomass is at an extremely high level. As a result, the SSC has continued to apply the default control rule. Applying 75 percent of FMSY to the projected biomass, the stock has been comfortably below the overfishing threshold, every time this stock has been assessed. This is probably due largely in part that the fishery does not come close to catching the ABC.

For cod, it's a different story. Cod are well below the biomass threshold and well above the fishing mortality threshold. The model performance, which is good in terms of the retrospective bias for haddock is a little worse for cod.

Given this diagnostic problem, as well as the status of the stock, what the SSC has done is project out one year and apply 75 percent of FMSY to the projected biomass and then hold that ABC constant for years 2 and 3. Holding the ABC constant would build a bigger buffer between the ABC and the OFL through time. So the OFL is still based on projected biomass, but holding the ABC constant as the projections suggest, leads to a bigger buffer as uncertainty increases.

With the Georges Bank yellowtail flounder in addition to the lack of recovery and biomass is the lack of recovery in age structure. Fishing mortality has been reduced considerably but without any concomitant biomass recovery, but it was thought that the age structure might recover. This, however, is not happening and continues to be a cause for concern. Along with all of the other biological and scientific issues described previously, the SSC has moved fully away from the default control rule here, due in part to the fact that there is no longer have an approved analytical assessment model. The status is unknown. So the SSC uses an exploitation rate applied to the estimated survey biomass.

The Risk Policy Working Group to try to give better guidance to the SSC in setting ABCs with a more explicit definition and explicit tolerance for risk, an approach that can be applied across stocks and FMPs. The group has set out three major goals. The first is to basically improve understanding and come to a common understanding across the SSCs and the Council about what risk is what it means and how we define it.

The second goal is to then provide a structure for how the SSC both accounts for risk and then applies that accounting in both the science and management process.

The third goal is to improve both consistency and clarity in the rationale for how we set ABCs and ACLs across fisheries.

The more specific objectives this group has set out are to, one, more clearly identify the Council's risk tolerance, essentially to bound its risk tolerance, again, in the opposite direction, risk aversion. Within those bounds, then come up with ways to respond to different levels of uncertainty and stock conditions. Going forward, to improve the science needed to analyze and understand risks.

The group suggested that the SSC start out fairly simple in the questions that were asked, the analytical approaches applied, and have this be a progressive process where through time to try to improve the information base, perhaps use more complex analytical tools and ask more questions and investigate more dimensions of risk, including the biological, ecological, social and economic aspects.

Questions and Answers to the Round Robin Presenters

Initial discussion focused on the 'rumble strip' approach developed by the Mid-Atlantic Council, which raises flags when stock assessments need to be updated. It was noted that the rumble strip worked well for some species, such as summer flounder, but not so well for others. Further, some of the data sources used for the rumble strips are not include in the Mid-Atlantic Council's MSE operational model.

This was followed by discussion on the analogy of weather forecasts and fish forecasts from stock assessment models, and whether this was an appropriate analogy. One point of divergence was that feedback into weather models is relatively instantaneous, whereas this is comparatively less so for stock assessment models.

There was more discussion of the rumble strip approach. The Mid-Atlantic Council's motivation for using rumble strips was to reduce the number of updated assessments or operational assessments that are conducted every year. The SSC was looking at how a multi-year ABCs can be established. The rumble strips approach is a way to keep a check on what is happening during those multiple years, usually a three-year period. During that time if something hits a rumble strip it is not an automatic trigger to conduct an assessment, but a warning to take a closer look at the stock and the specified ABC.

The discussion then turned to the coefficient of variability of the probability of overfishing and the costs associated going from a CV of 0.38 to 1.0. This depends on the stock size. If it's above BMSY there is little to no cost associated with this, but it is significant if a stock is already overfished.

There was discussion about the effect of life history on the relative performance of control rules. Apparently, the performance tends not to change with life history. What changes are the periods between assessments and data lag; the longer the life history is the less effect there is by having that lag. This may be more of a fishing mortality rate effect because the target fishing mortality rates are so much lower for those stocks with the longer life spans, resulting in less change.

With respect to uncertainty, there was discussion about how this was communicated between the SSCs and the Councils. Further, there was comment about managing expectations of industry and stakeholders, in general. There was a need to communicate with stakeholders the fact that, for some of these species and stocks, there is so much inherent uncertainty which leads to an inability to improve the accuracy or precision in estimates. If there is a better appreciation of this uncertainty it may improve how stakeholders interpret and react to those uncertainties.

One way to deal with this is to provide a little more clarity about the sources and the treatments that are underway now and what the sort of implications of that are. A second way of dealing with that is to highlight the important work that is being undertaken at various levels from data inputs to models and assessment methodologies to some of the broader ecosystem-based approaches.

The discussion continued about characterizing uncertainty and whether this was less important than selecting an appropriate catch buffer that improves the performance of a stock.

The last item of discussion was about the difficulty of incorporating expert judgment in MSEs. Apparently, this has never been attempted.

Discussion Summary on Subtheme 2: Evaluating Existing Acceptable Biological Catch Control Rules: Issues, Challenges and Solutions

Each region has unique processes to specify ABCs, risk policies, harvest control guidelines, and uncertainty characterizations for the different fisheries in its fishery ecosystem/management plan. For example, New England uses the proportion of the F to F_{MSY} relative to catch to ABC as a metric for its fisheries. The National SSC V suggested creating a working group to look at existing control rules and management performance across all the regions and to develop criteria and standards based on common metrics.

Integrating Management Strategy Evaluation (MSE) into the fishery management process is another topic area of interest. Current risk policies are focused on preventing overfishing and measuring fishery outputs. MSE brings in other important and maybe more critical factors that are not necessarily biological in nature. A clear understanding of fishery objectives by the Council and stakeholders is important to make management performance measurable. Comparative analysis of various management/regulatory measures can be accommodated through an MSE-type process. Application of MSE would formalize expert judgment/opinion to advance a more strategic-oriented approach to management and would in turn help build trust in the science underpinning management. MSE can also be used to evaluate the utility and effectiveness of non-MSY based management strategies especially in data-limited areas where the fishery is multi-species and multi-gear and has low value and high effort.

Communication among the NMFS Fisheries Science Centers, SSCs, and Councils regarding the various aspects of the ABC control rule and the risks associated with the specified ABC is another issue. In some regions, the Science Center does not clearly understand the expectations of the SSC and the SSC has no clear guidance from the Council on the science it needs in order to make management decisions.

Regions that are data poor have growing concerns about ecologically important species, which are, to some extent, keystone species. Fishery managers and scientists are being increasingly pressured to increase understanding of the ecology and dynamics of these species and to approach their ABC specifications more conservatively. In the Caribbean, a lawsuit triggered the reevaluation of the ABC specifications for parrotfish and angelfish relative to these species' roles as herbivores in protecting endangered coral species. Similarly, on the East Coast, environmental groups pushed for consideration to be given to the ecological importance of forage fish to marine mammals. With pressure coming from various sides, prioritizing species for research and stock assessments becomes challenging. The NMFS stock assessment prioritization process accommodates ecological importance of species.

In the North Pacific, ABC specifications are tied to the generation of stock assessments, updates are tied to new information coming from new surveys, and MSEs are used to inform the Council on proposed changes to management approaches on a case by case basis. Using new information builds confidence in the assessments. The success of the North Pacific system is seen in its generation of stock assessments (45 per year) tied to the monitoring system and the ability of the SSC to review the assessments. The CIE often reviews one or two assessments per year, and the CIE provides recommendations directly to the authors on ways to improve the assessment. The CIE comments, and the assessment response, are shared with the plan teams and SSC. More frequent stock assessment updates are conducted in order to increase the assessment throughput. Meanwhile, the West Coast process builds upon identified information gaps during the assessment review to generate research priorities. Once the data are gathered, the information is incorporated in the assessment. The East Coast process may result in a complete overhaul and advances may follow a different path.

Findings and Recommendations

- A generalized approach may be needed for MSEs with specific objectives (e.g., evaluating control rules or setting overfishing limits) to allow cross regional comparisons and use.
- In setting ABCs, consideration should be given to species, or species within a complex, as to whether the species plays an important role in the ecosystem (e.g., keystone and forage species).
- Report on the retrospective performance of ABCs, based on the development of consistent performance measures that are common to all regions.
- Strive for consistency in describing risks associated with ABCs across regions.

Prior to the continuation of the National SSC meeting, there was a short ceremony to honor Mr. Frank Goto General Manager of United Fishing Agency since the mid 1960s to the present, and one of the first Council Members after the creation of the Magnuson Act in 1976. Mr. Goto was also an original member of the Marine Fisheries Advisory Committee (MAFAC), which advises the Secretary of Commerce on all living marine resource matters that are the responsibility of the Department of Commerce.

SUBTHEME 3.a:

Incorporating Ecological, Environmental, and Climate Variability in Stock Assessment and Ecosystem-Based Fishery Management: Part 1

Keynote Presentation: Incorporating Ecological, Environmental, and Climate Considerations in Stock assessments and Ecosystem-Based Fishery Management

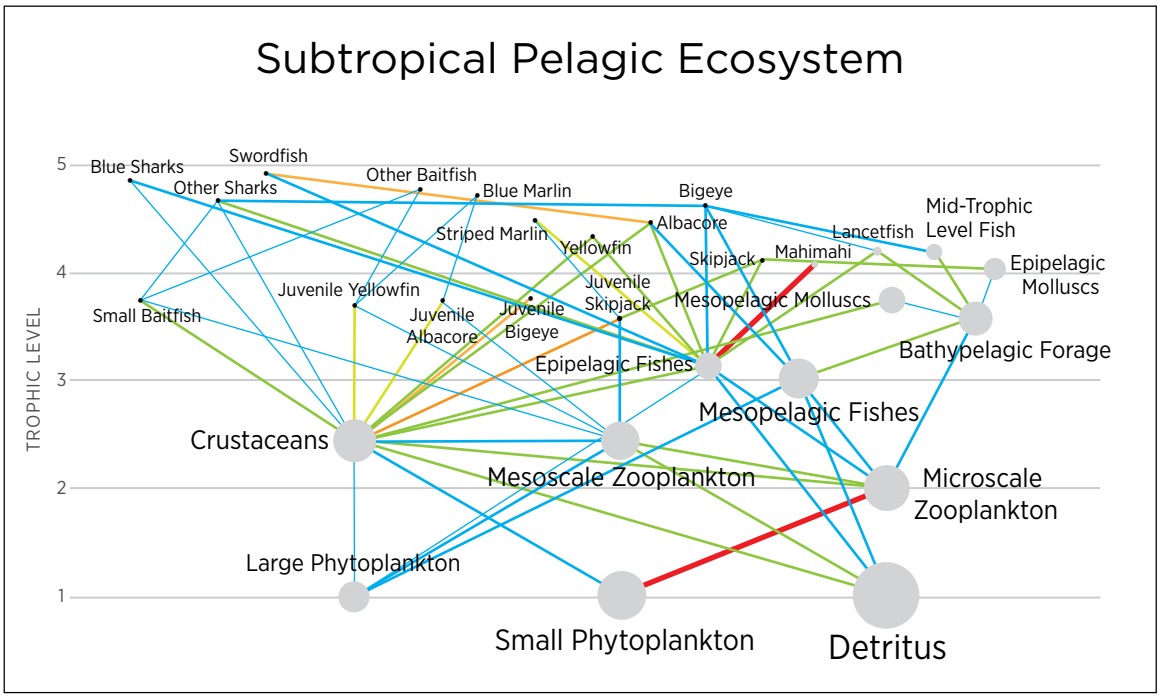
Speaker: **JEFFREY POLOVINA**, NMFS—Pacific Island Fisheries Science Center

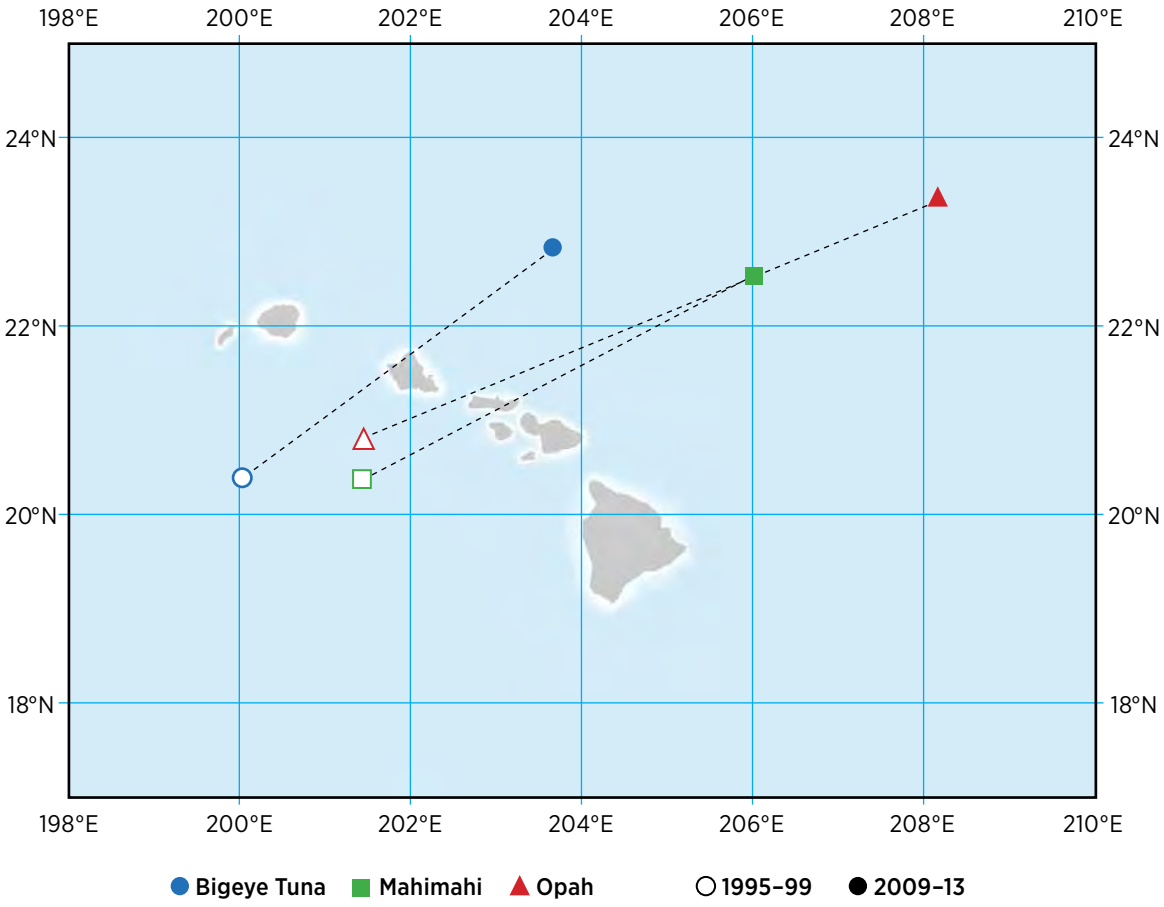
Jeffrey Polovina

It has long been recognized that fish populations respond to environmental variation. Thus it is appealing to consider accounting for this variation in stock assessments. Situations where incorporating environmental variables might prove most beneficial and some challenges encountered are discussed. An emerging approach consists of presenting time series of key environmental and ecosystem indicators to augment stock assessments, often called ecosystem considerations chapters. This approach incorporates both environmental and ecosystem changes but often can be more qualitative than quantitative.

Ecosystem models offer the potential to contribute in a number of ways including quantifying ecosystem changes, projecting climate impacts, estimating multispecies MSY, and serving as a framework for management strategy evaluations and to evaluate indicators and tipping points.

We are also keeping track of the spatial dynamics of the Hawaii longline fleet. At the beginning of the 1990's the center of gravity or center of mass of the bigeye and mahimahi catches were to the south of the Hawaii archipelago. More recently, these have shifted over to northeast of the islands. Going forward, the combined use of single species and ecosystem models may hold promise.





Discussion Summary on Subtheme 3.a: Incorporating Ecological, Environmental, and Climate Variability in Stock Assessment and Ecosystem-Based Fishery Management: Part 1

Each region has a different strategy in its use of ecosystem models and ecosystem considerations in fishery management. Data-rich regions use ecosystem models in a tactical manner to predict the strength of recruitment (e.g., salmon, sardines) from which they can make appropriate adjustments to the harvest controls. Other regions use ecosystem indicators and environmental variables in risk policies of their respective Council. Most regions have no multispecies ecosystem models developed specifically for management use.

Commonalities among the regions are the lack of technical expertise to generate or develop ecosystem models and the shared goal to be able to predict or forecast fishery productivity in order to make suitable adjustments in the setting of ABCs and ACLs.

Two regions have used climate models for multispecies projections through various climate research programs. The goal was to assess performance of alternative harvest strategies as affected by a changing climate regime. The North Pacific Region utilized the regime shift of 1976-77 and its impact on ecosystem structure and fish production as a factor in estimating biological reference points in several assessments. The SSC requested that the authors of the ecosystem considerations chapter annually report on a discrete suite of leading ecosystem indicators as well as any unusual ecosystem conditions. The status of these indicators is considered prior to discussions to set biological reference points. Authors of stock assessment reports include an ecosystem section

that focuses specifically on potential interactions with the assessed species. The Pacific Region proposes a three-pronged approach to move forward with ecosystem-based fisheries management: 1) incorporate environmental variables into single species stock management; 2) enhance use of ecosystem models by the Council to evaluate ecosystem impacts to fisheries; and 3) incorporate the integrated ecosystem assessment (IEA) process into the Council process.

Regarding the incorporation of environmental variables into single species assessments, the National SSC V noted that some regions could explore approaches that are somewhere between attempting to identify specific environmental covariates as drivers and treating environmental effects as purely random noise. The model can be configured to use an auto-correlated error structure for recruitment deviations in assessments and forecasts, as environmental conditions are typically temporally auto-correlated.

The Pacific Region developed an Atlantis model for the California current ecosystem. The model was applied to analyze food web impacts, such as evaluating trophic impacts of forage fish harvest policies on abundance and yield of other fishery species and ranking of potential fishery management strategies; to evaluation of risks of climate change and ocean acidification; and to "simulate test" with MSE new methods of stock assessment, data collection, and metrics for indicators of ecosystem attributes.

The Pacific Region SSC recommended that other SSCs begin to think about review of ecosystem models and IEA reports as the next steps toward incorporating ecosystem-based fishery management (EBFM) into the Council process.

Findings and Recommendations

- National guidance is needed on: a) appropriate responses to sudden changes in parameters; b) a systematic approach to determining keystone species for which ecosystem-based reference points might be needed; c) costs and benefits of considering multispecies models alongside single species models during the assessment process; and d) determining when a regime shift or other major environmental change compels a change in parameter inputs and resultant reference points.
- Enhance regional capabilities to examine ecosystem dynamics and the effects of natural and anthropogenic factors on production dynamics of exploited species.
- Enhance research to model both the extent and the strength of interrelationships among environmental factors, as affected by climate change and habitat associations of the different species in the fishery to gain a better understanding on how to offset the impacts.
- Incorporate ecosystem considerations into stock assessments when appropriate; otherwise, ecosystem considerations or information can be supplementary information.
- Incorporate an ecosystem-based fisheries management framework into the Council process via review of ecosystem models and IEAs applicable to the fisheries being managed.

SUBTHEME 3.a:

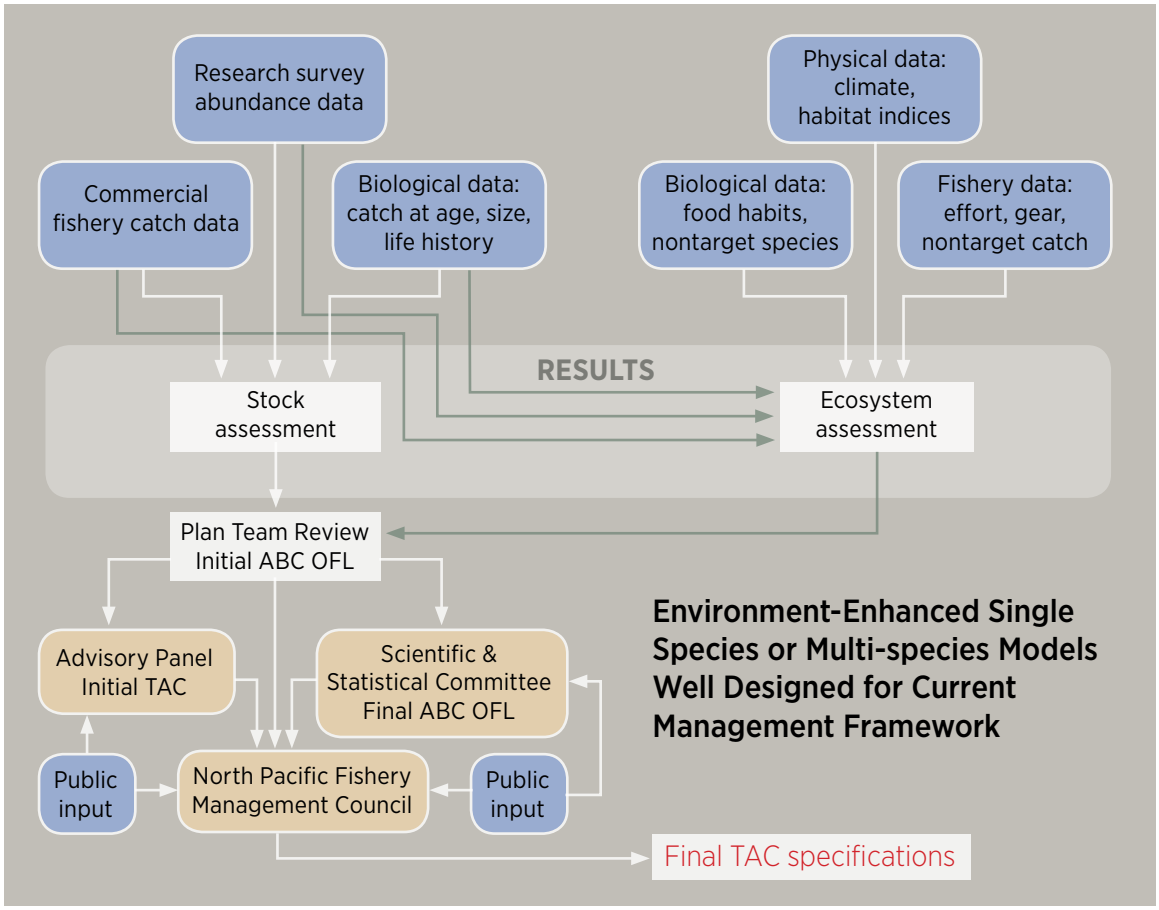
Incorporating Ecological, Environmental, and Climate Variability in Stock Assessment and Ecosystem-Based Fishery Management: Part 2

Keynote Presentation: Projecting Climate Change Impacts on Fish and Fisheries

Speaker: **ANNE HOLLOWED**, NMFS—Alaska Fisheries Science Center

Anne Hollowed

The proliferation of modelling improvements and global projections creates a dilemma for regional ocean modellers and fisheries scientists as the number of possible permutations that could be explored rapidly can become too large to manage. Identifying a reasonable range of representative futures (with sufficient contrast in scenarios) and biological models is needed to allow analysts to compare projections and report on the relationship between model complexity, efficiency, and the computational costs of increased ecological realism in models. This talk describes international strategies to develop quantitative projections of future responses of fish and fisheries to expected changes by 2019. To move beyond qualitative projections of future impacts scientists are striving to extend regional models to include projections of climate impacts on the distribution and abundance of commercial fish and fisheries. A case study for the Bering Sea is used as an example of the proposed multi-model approach to climate change projections. Strategies for Fisheries Management Council action to engage stakeholders in the development of the suite of representative fishing scenarios are discussed.



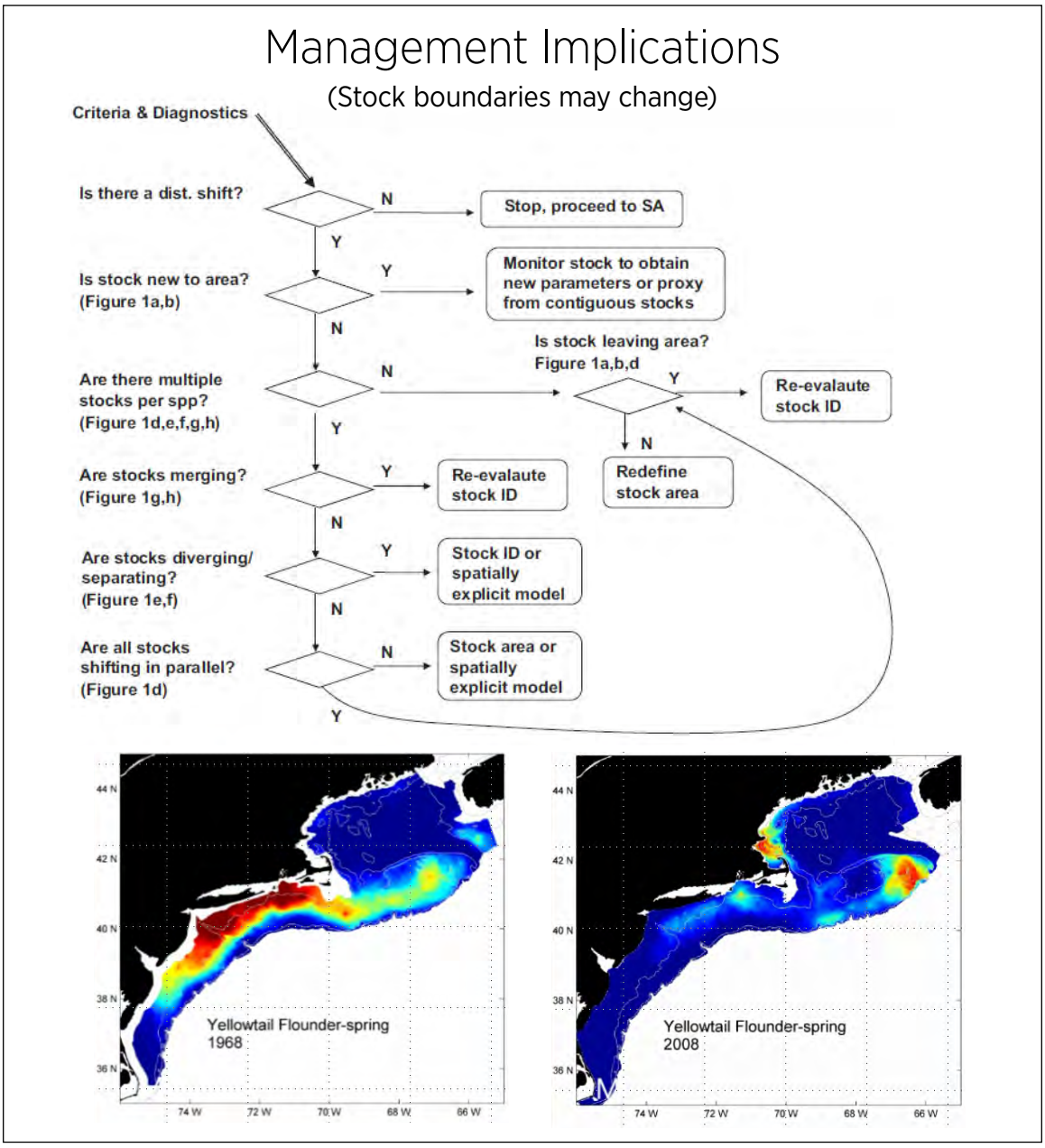
SOURCE: NOAA FISHERIES. HOLLOWED, ET AL. 2011. *FISHERIES AND FISHERIES* 12: 189–208.

In conclusion climate change will impact marine ecosystems and thus fish and fisheries:

- So far quantitative projections of the magnitude of change have been completed for only a few species
- Scenarios may differ depending on the climate model, the RCP scenario, and the complexity of ecosystem models.
- National and international modeling teams are striving to produce quantitative scenarios for major stocks by 2019

SSC Roles:

- Identifying a reasonable range of management responses (or fisher responses) for projections
- Selection of performance criteria
- Review of models – especially SSCE and MSCE
- Review of management strategies



LINK ET AL. (2011) FISH & FISHERIES 12:461–469

Keynote Presentation: Shifting Species Distribution with Climate Change

Speaker: **JONATHAN HARE**, NMFS—Northeast Fisheries Science Center

Fishery species have been shifting distributions for decades and these changes have rarely been incorporated explicitly in stock assessments and management. Numerous studies have now documented changes in species distributions related to climate change. In general, species are moving poleward and into deeper waters. However, it is important to recognize that this is a general pattern and that there are a substantial number of exceptions. The global evidence of shifting distributions will be reviewed and the causes of shifting distributions will be identified (primarily climate change and fishing). Factors that contribute to the general northward / deeper pattern will be discussed as will factors that are responsible for exceptions. The relevance of shifting distributions to fisheries assessment and management then will be addressed: availability, stock structure, spatial allocations, and closed areas to provide a partial list. Finally, tools that are developing to project / predict distributions in the future will be summarized and areas where more work is needed to improve these tools will be identified.

In summary:

- Climate is a past, present, and future issue
- Distribution shifts identified in 1957
- Distribution shifts quantified in 1993
- Part of National Standard 1

Management Implications:

- Need to develop Ecosystem-Based Fisheries Management
- Account for complexity of ecosystems (including climate)
- Account for complexity of human interactions

Discussion Summary on Subtheme 3.a: Incorporating Ecological, Environmental, and Climate Variability in Stock Assessment and Ecosystem-Based Fishery Management: Part 2

The biggest challenge dealing with climate change is the uncertain impacts to fishery stocks. One expected impact is the shifting of the species distribution, so a Region could face species with which it had not dealt with previously. The management structure should accommodate better collaboration and partnership among Councils and/or between governments to manage shared transboundary stocks if species range expands, or to transfer management authority if species relocate to another management area. Councils need to lay the groundwork to enhance collaboration between regions and ensure that the whole ecosystem is covered. Collaboration between adjacent jurisdictions should begin early when distribution shifts are evident, so a smooth transition can take place to avoid disruption in the fisheries management and assessment process and the fishery itself. Increasing cross fertilization between SSCs and Councils will allow for a coordinated work on common issues affecting different regions. In addition to developing or enhancing regional collaboration, guidance needs to be developed to separate science and management strategies related to decreased species biomass either due to lowered productivity or species relocation to other jurisdictions.

Some regions are successfully incorporating environmental parameters in single-species assessments. However, explicit procedures need to be developed for deciding when and how to modify reference points or develop harvest control rules that will perform well under various climate change scenarios.

An ecosystem approach to fishery management may be a more cost effective means for managing stocks than the usual quota-based approach for regions that are dominated by data-poor or data-moderate stocks. Transitioning to EBFM will enable a more holistic evaluation of anthropogenic impacts.

Different regions are in different phases of transition to EBFM, under which climate change considerations fall. Regions need to deal with climate issues in an incrementally and progressive way, rather than deal with them intermittently once a problem and its impacts are at hand. Expected changes in factors need to be identified and incorporated into monitoring programs, so that the changes can be detected quickly and immediately used in assessments and management. These issues should be addressed across the full range of possible scenarios. Councils need to develop a contingency process for management in light of potential climate change impacts on communities, stakeholders, and the fishing industry based on scenarios predicted by the ecosystem models.

Regime shift is usually associated with climate change. The rate and extent of the shift's impact on stocks may not currently be predictable. Regime shifts are a system level effect, which will impact multiple stocks at the same time but potentially at different rates. The indicators being monitored should have thresholds to signal when the regime shift occurs. Monitoring the indicators and knowing the threshold are the keys.

Not all regions have the capacity, resources, and/or data to develop ecosystem models. In areas where ecosystem models are still being developed, a systematic approach is needed to identify vulnerable stocks that are sensitive to climate change and lack resilience to change. Vulnerability assessments are needed to evaluate important habitats, climate change impacts to the habitats, and the existing factors impacting the species.

Each region has different climate related factors that may have more effect on its stocks than changes in temperature. These factors may drive species distribution and can change assessment and management needs. Identifying these specific factors is essential. Models should differentiate between distributional shifts and productivity shifts. Genetics may help distinguish the difference. There is a need to improve cross boundary data collection and assessments. It would also behoove Councils to engage IEA teams to support the development of ecosystem models for fishery management.

Findings and Recommendations

- Regions with adjacent jurisdictions need a mechanism for collaboration so management strategies are consistent and conflicts in management goals are avoided, particularly when species populations shift due to climate change impacts.
- Develop national-level and regional-level guidance for catch quota recommendations for stocks that have shifted distributions (due to climate change, spatial changes in productivity, etc.) into adjacent management jurisdictions.
- Develop appropriate monitoring frameworks to assess the impacts of ocean acidification and increased sea surface temperature on stock productivity in vulnerable ecosystems, like coral reefs, and establish contingency management measures to respond to such changes in fishery resource availability, distribution, and quality.
- Conduct vulnerability assessments to determine which stocks are likely to be impacted by climate change.
- Incorporate environmental variables in assessments, where appropriate.
- Use ecosystem models to evaluate impacts of fisheries and other factors on fishery stock productivity.
- Engage various IEA teams to develop useful products to assist Council decision-making

SUBTHEME 3.b:

Building Habitat Conditions into the Stock Assessment Process and Fishery Management Strategies

Keynote Presentation: The Habitat Assessment Improvement Plan: Habitat Data to Enhance Stock Assessment

Speaker: **THOMAS NOJI**, NMFS—Northeast Fisheries Science Center

Thomas Noji

In response to the ever-increasing demands placed on marine habitats across many sectors of the U.S. economy, and due to our poor understanding of the dependence of marine fisheries on habitat availability and condition, the *Marine Fisheries Habitat Assessment Improvement Plan* (HAIP) was published in May 2010. The Plan was the product of two years of preparation by scientists in each of the six NMFS Science Centers and the Office of Science and Technology. The HAIP is predicated upon the understanding that gaps in NMFS' habitat science constrain our attempts to achieve sustainable fisheries. The Plan is intended to help close those gaps and be the foundation for a nationally-coordinated fisheries-focused habitat science program.

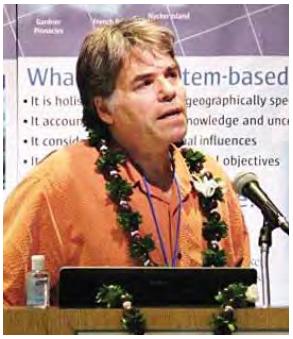
The HAIP is centered on several goals to support sustainable fisheries, including the reduction of habitat-related uncertainty in stock assessments, and the incorporation of ecosystem considerations and spatial analyses. Although the HAIP has not to date generated a large, steady line of funding as was the case for the Stock Assessment Improvement Plan, the agency has provided some funding targeting initiatives aimed to enhance stock assessments through marine habitat research. This science has been diverse and is delivering data focusing on habitat characterization and mapping, vulnerability of species to degrading habitat condition, metabolic rates and behavior in relation to habitat condition, and affinity of species to dynamic 3-dimensional habitat. These findings can be used to improve survey design, the accuracy of models and more generally the breadth of information to support fisheries management decisions. Multiple examples are given to illustrate the utility of this information to enhance stock assessments.

Outcomes and Future Directions:

- Yearly funding to support habitat research in support of stock assessment
- Refocusing of climate, ecosystem and habitat research to support assessment processes for managed species
- National habitat science synergy
- National habitat science strategy
- Prospect for future funding initiatives
- Effects of broad-scale change on habitat and associated species
- Improved joint prioritization of research and limited funding
- A place in fisheries management plans

Keynote Presentation: Aspects of Habitat of Particular Concern for Fish Population Dynamics and Fishery Management

Speaker: **JOHN MANDERSON**, NMFS—Northeast Fisheries Science Center

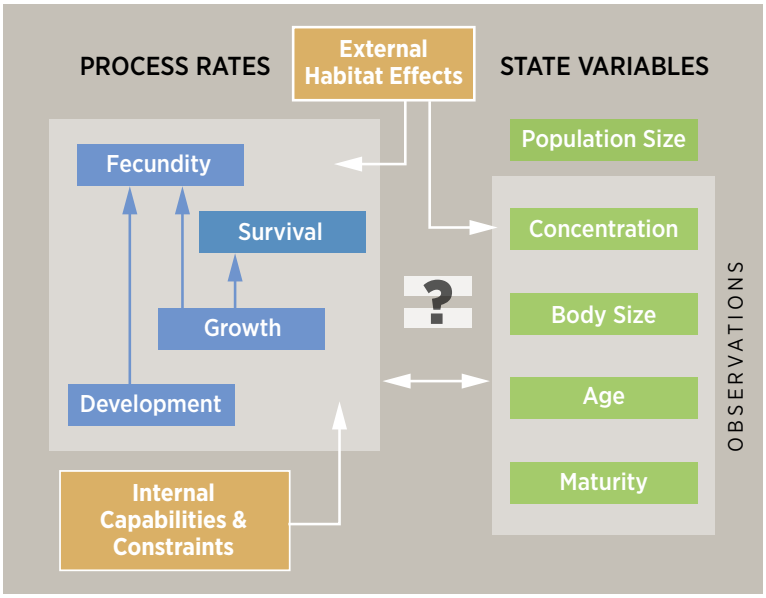


John Mandersons

Habitat ecologists charged with developing products useful for the assessment and management of marine populations and ecosystems face two competing challenges. To meet requirements of fisheries stock assessment, we are challenged to "trade space for time" and develop quantitative indicators of habitat effects on recruitment processes that can be integrated into models of population dynamics. These habitat indicators usually make spatial habitat characteristics implicit in order to develop time series of seasonal to inter-annual changes in ocean structure likely to affect important life history processes at the spatial extent of whole populations. In contrast, tactical ecosystem management, which currently emphasizes spatial management, requires that we "trade time for space" and produce high resolution maps of habitat conditions that ultimately result in the successful completion of species life histories through reproduction. It is often expected that habitat conditions represented in these maps will be stable over long time scales that sometimes match those of human governance systems more closely than the ocean ecosystems they are designed to represent.

An attempt was made to identify which of these competing demands can be met operationally by habitat ecologists, right now, given the nature of ocean habitat and the data and analytical approaches available and accepted by fisheries stock assessment and management communities. In many regions, the development of habitat information for fisheries management is based on species-environment relationships statistically extracted from field surveys used in stock assessments. These analyses assume that dependent variables (presence-absence, abundance, body size, species diversity) vary directly with habitat suitability. Furthermore, the surveys; designed to develop precise estimates of mean population size at annual time scales; have sampling grains, lags and extents that are coarse in both space and time with respect many important species-habitat relationships in the sea. As a result statistical analyses of stock assessment survey data are most useful for describing dynamic species-habitat associations at scales of 10s of kilometers and 6 to 12 months. These associations are typically related to the geographic range and seasonal migration dynamics of populations. The analyses are therefore less useful for developing high resolution spatial maps required for tactical management than for integrating the potential impacts of habitat suitability at macro-ecological scales into stock assessments.

An example is presented of a "macro-ecological" scale analysis and modeling of thermal habitat designed to inform population assessment. The analysis used a coupled thermal niche-ocean model to investigate the potential impacts of habitat dynamics on observations of population size as well as habitat availability on population demography for an important forage species, long fin inshore squid, on the northeast US continental shelf. Multi-model inference indicated that the statistical model with the strongest support included terms for habitat effects on demographic as well as the observation process. Spring population size increased with the quantity of thermal habitat available during the winter when the dominant demographic process affecting squid appears to be natural and fishing mortality. However, estimates of spring population size were also smaller when the proportion of thermal habitat sampled during the spring survey was small. Furthermore, the effect of habitat on the survey observation process was much stronger than habitat effects on demography. While the indicators of habitat surveyed and habitat available in the winter were not correlated, the results, nevertheless, suggest that there is a risk of confounding habitat effects on survey observation and demographic processes. Both types of habitat effects need to be explicitly



taken into account to integrate ocean habitat dynamics into models of fish population dynamics in a manner that can improve the accuracy of assessments informing fisheries management.

It is becoming increasingly clear that the effects of ocean habitat dynamics on survey observations and on population demography are often not random but can show strong trends. Violations of the stationarity assumption of traditional stock assessment models have become more likely because of systematic, human induced, changes in the climatology of the atmosphere and the ocean. Habitat information describing environmental effects on species vital rates to the degree and at scales that affect population dynamics needs to be developed to more accurately assess and effectively manage wild capture fisheries in the face of anthropogenic climate change. Habitat information required for forecasting a future in which novel habitat conditions are likely to emerge, needs to be developed using approaches that move beyond statistical analysis of coarse scale species-environmental correlations that can be gleaned from stock assessment survey data. Approaches that combine field surveys stratified on the basis of ocean habitat features suspected to directly affect species vital rates underling population growth, with mechanistic experiments that can more precisely parameterize environmental effects on species vital rates are required. The mechanistic biological models that result can then be coupled with regional scale ocean models that capture the processes and properties of the water column as well as the seabed. Projections of habitat suitability made using with coupled models will allow us to better understand and represent habitat effects on species distributions and demographic rates at space-time scales useful for the assessment and management of marine ecosystems.

Discussion Summary on Subtheme 3.b: Building Habitat Conditions into the Stock Assessment Process and Fishery Management Strategies

Regions with developed fisheries that are data-rich use habitat information as either spatial and/or habitat effects in single-species assessments and ecosystem models. Consideration of spatial and/or habitat effects can improve the precision of abundance indices from both fishery-dependent and fishery-independent survey data. For example, fishery-dependent information is being used to develop recreational indices in upcoming nearshore rockfish stock assessments in the Pacific Region. Geo-statistical delta Generalized Linear Mixed Models have been developed to make use of fishery-independent information. This method statistically models spatial autocorrelation, which implicitly incorporates the effect of unmeasured habitat attributes. The South Atlantic is using habitat information gathered through bottom mapping activities, along with temperature, depth, habitat type, location, and other factors to develop indices of relative abundance for stock assessments.

The importance of habitat considerations has been recognized in the South Atlantic, as evidenced in its consideration of essential of fish habitat (EFH) in the fishery management plans (FMPs) for corals and sargassum, as well as its comprehensive ecosystem FMP. The South Atlantic also considers habitat in the designation of marine protected areas (e.g., to protect grouper and tilefish) and habitat areas of particular concern (HAPC) as well as in the management of artificial reefs.

In the North Pacific, the NMFS Regional Office has developed a Catch-in-Areas database by using haul-by-haul catch information to provide detailed catch information on a smaller geographic scale. This allows analysts to examine the intensity of fishing effort (and catch) by different gear types, areas, and fisheries. The NMFS Office of Science and Technology is also looking at the amount of habitat that cannot be trawled, which may help resolve some trawl survey and stock assessment issues. Research funded by NMFS's Habitat Assessment Improvement Plan (HAIP) has helped define ecoregions in the Bering Sea. Generalized Additive Models can estimate habitat suitability for deep-water corals. The Mid-Atlantic Council is developing an FMP amendment to conserve and protect deep-water corals by using a habitat suitability index to predict the occurrence of corals.

The Gulf Council has a written habitat policy in addition to a generic amendment for addressing EFH requirements within its FMPs. The overall goal of the policy is to "protect, restore, create, and otherwise improve EFH upon which commercial and recreational marine fisheries depend and to improve their productive capacity for the benefit of present and future generations." The policy objectives are to: 1) maintain the diversity and productive capacity of habitats in a quantity needed to sustain managed fisheries and their food base; 2) restore and rehabilitate the productive capacity of habitats that have already been degraded; and 3) create productive habitats where increased fishery productivity will benefit society.

In New England, EFH is a somewhat limiting concept in developing management measures because most areas are EFH for one or more species. Hence, New England factors additional considerations, especially the rarity and vulnerability of different habitat types, in its management measures. Areas that need management attention due to those considerations extend beyond areas designated as HAPCs and are referred to as Habitat Management Areas. Additional areas include Designated Habitat Research Areas and spawning protection areas, which at this time are being considered for enhancing spawning success of only groundfish.

The Gulf Region has several HAPCs that are protected entirely or seasonally from fishing. A total of 280,800 km2 of offshore and coastal habitats in the Gulf are under some form of protection. Nonetheless, the habitat characteristics of broad areas of the region remain unknown. Ongoing studies, some of which have been funded by HAIP, are adding to the inventory of the Gulf's known pelagic and benthic habitats. Hypoxia, the Deepwater Horizon oil spill, destructive fishing gears, and the ecological versus fishery function of artificial reefs are pressing habitat-related issues affecting fisheries sustainability in the Gulf.

The Caribbean and Western Pacific Regions are primarily concerned with coral reef habitat. Coral reef fish distributions are strongly affected by benthic habitat type, location, and condition. Other important components are: 1) water quality (e.g., turbidity, sewage discharge), which is exacerbated by narrow insular shelves that allow watershed activities to impact areas across the shelf; 2) landscape considerations due to the highly patchy nature of key habitats across the shelf (e.g., sea grass, mangroves, and shallow, mesophotic, and deep reefs), as fish diversity, abundance, and productivity are enhanced in areas of high habitat diversity; and 3) varied use of habitat across species and ontogenetic stages, which results in all habitat types being identified as EFH, a result that is not helpful for prioritization.

Dependence upon benthic features varies among managed species. That dependence should be described and will determine the extent to which benthic properties should be factored into both assessment and management, specifically protection and/or restoration strategies. Similarly, responsiveness to properties of the water column will vary among managed species. Properties of the water column cannot be affected as

readily by management, but management can still respond to those properties and incorporate them into models, when they improve predictive capabilities or into dynamic spatial management strategies.

One commonality across all regions is that EFH and HAPC are used separately and do not feed directly into fishery management decisions. They are being updated regularly, are thoughtfully designated, but are used merely for consultation purposes.

Findings and Recommendations

- More information is required on the relationship between habitat attributes and stock productivity, as this information has direct impacts on stock assessment advice, leading to linking habitat impacts and ecosystem-level productivity.
- Consideration should be given to an additional National Standard to minimize non-fishing impacts to EFH.
- New tools are needed to analyze habitat information and develop management measures, particularly to distinguish resilient EFH areas and less resilient EFH areas, which may need additional management.
- Strengthen mechanisms to integrate watershed impacts on EFH and fisheries productivity, as well as linkages to local jurisdictions.
- Define EFH on a multispecies, multi-habitat basis to identify key shelf areas for priority protection.
- Engage local jurisdictions when designating marine reserves in key inshore areas within a larger network.
- Provide additional attention to key life history patterns, particularly spawning habitat, spawning aggregations, and nursery habitat, especially in shallow environments that have heavy anthropogenic or climate impacts.

Appendix I: Agenda

2015 National Scientific and Statistical Committee Workshop-V

Ala Moana Hotel, Honolulu, HI | February 23–25, 2015

Agenda: "Providing Scientific Advice in the Face of Uncertainty: from Data to Climate and Ecosystems"

22 February 2015 (Sunday)

TIME: **Speaker/Leader**

1500–1800 EARLY REGISTRATION (Gardenia)

23 February 2015 (Monday)

0730 REGISTRATION

0830 1) Welcome remarks . . . . . .Kitty Simonds
2) Introductions . . . . . Charles Daxboeck

3) **SUBTHEME 1.a: ABC Specification for Data-Limited and Model-Resistant Stocks**

0850 A. *Keynote Presentation: Managing data-poor fisheries down under*
Speaker: Malcolm Haddon, Commonwealth Scientific and Industrial Research Organization (CSIRO)

0935 B. *Keynote presentation: Progress and roadblocks in the estimation of stock status and catch limits for global fisheries*
Speaker: James Thorson, NMFS – Northwest Fisheries Science Center

C. Round Robin Session: Setting ABCs for data-limited / model-resistant stocks (with emphasis on problems in the specification process for stocks with limited to no data or with data but not usable for existing modeling framework)

1010 NPFMC . . . . . Farron Wallace
1020 WPFMC . . . . . Robert Skillman

1030 Morning Break

1050 PFMC . . . . . Meisha Key
1100 GMFMC . . . . . William Patterson
1110 CFMC . . . . . Richard Appeldoorn
1120 SAFMC . . . . . Luiz Barbieri
1130 MAFMC . . . . . .John Boreman
1140 NEFMC . . . . . Jacob Kritzer
1150 NMFS—"Stock assessment prioritization tool" . . . . . .Rick Methot
1200 D. Preliminary Q&A to the presenters

1220 Lunch Break

1330 E. *Plenary Discussion: ABC specification for data-limited and model-resistant stocks*
Terms of Reference 1.a. and Trigger Question Set 1.a.
Session Facilitator: Samuel Pooley
Rapporteurs: Joshua DeMello, WPFMC; John DeVore, PFMC

4) **SUBTHEME 1.b: Implementation of National Standard 2 in the Face of Uncertainty**

1430 A. *Keynote Presentation: National Standard 2 in determining best scientific information available*
Speaker: Rick Methot, NMFS – Office of Science and Technology

1515 Afternoon Break

1530 B. *Plenary Discussion: Implementation of National Standard 2 in the face of uncertainties*
Terms of Reference 1.b and Trigger Question Set 1.b
Session Facilitator: Jacob Kritzer, SSC Chair NEFMC
Rapporteurs: Paul Dalzell, WPFMC; Graciela Garcia-Moliner (CFMC)

1630 5) Develop specific recommendation to the CCC for subtheme 1

1730 Adjourn for the day

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24 February 2015 (Tuesday)

6) **SUBTHEME 2: Evaluating existing ABC control rules: issues, challenges and solutions**

0830 A. Keynote Presentation: Addressing uncertainties in stock assessment in a variable environment
Speaker: Eric Schwaab, National Aquarium

0900 B. Keynote Presentation: Use of Management Strategy Evaluation to assess performance of harvest control rules
Speaker: André Punt, School of Aquatic and Fishery Sciences, University of Washington

0930 C. Keynote Presentation: Comparing Performance among Alternative ABC Control Rules
Speaker: Michael Wilberg, Center for Environmental Science, University of Maryland

1000 Morning Break

D. Round Robin Session: Evaluation of the current ABC control rules (with emphasis on how each council monitors the performance of the control rules, issues, challenges, and solutions)

1020 NPFMC . . . . . Farron Wallace
1030 WPFMC . . . . . Robert Skillman
1040 PFMC . . . . . Meisha Key
1050 GMFMC . . . . . William Patterson
1100 CFMC . . . . . Richard Appeldoorn
1110 SAFMC . . . . . Luiz Barbieri
1120 MAFMC . . . . . John Boreman
1130 NEFMC . . . . . Jacob Kritzer

1140 E. Preliminary Q&A to the presenters

1200 Lunch Break

1300 F. *Plenary Discussion: Evaluating existing ABC control rules: issues, challenges and solutions*
Terms of Reference 2 and Trigger Question Set 2
Session Facilitator: John Boreman, SSC Chair MAFMC
Rapporteurs: John Froeschke, GMFMC; Mike Errigo, SAFMC

1400 7) Develop specific recommendation to the CCC for subtheme 2

8) **SUBTHEME 3.a: Incorporating ecological, environmental, and climate variability in stock assessment and ecosystem based fishery management**

1445 A. *Keynote Presentation: Incorporating ecological, environmental, and climate considerations in stock assessments and ecosystem-based fishery management (45 min)*
Speaker: Jeffrey Polovina, NMFS – Pacific Island Fisheries Science Center

1530 B. *Plenary Discussion: Incorporating ecological, environmental, and climate variability in stock assessment and ecosystem based fishery management*
Terms of Reference 3.a (Part 1) and Trigger Question Set 3.a (Part 1)
Session Facilitator: Samuel Pooley
Rapporteurs: Paul Dalzell, WPFMC; Richard Seagraves, MAFMC

1630 Adjourn for the day

National SSC-V: Poster and Display Viewing Session
6:00 pm Harbor View Center, Pier 38, 1129 North Nimitz Hwy Honolulu, HI 96817
Shuttle Departure from Ala Moana Hotel at 5:15 pm
Return Shuttle Departure from Harbor View Center at 8:30 pm

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25 February 2015 (Wednesday)

0830 D. *Keynote presentation: Projecting climate change impacts on fish and fisheries*
Speaker: Anne Hollowed, NMFS – Alaska Fisheries Science Center

0915 E. *Keynote presentation: Shifting species distribution with climate change*
Speaker: Jonathan Hare, NMFS – Northeast Fisheries Science Center

1000 Morning Break

1020 F. *Plenary Discussion: Incorporating ecological, environmental, and climatic variability in stock assessments and ecosystem based fishery management*
Terms of Reference 3.a (Part 2) and Trigger Question Set 3.a (Part 2)
Session Facilitator: Samuel Pooley
Rapporteurs: Eric Kingma, WPFMC; Chris Kellogg, NEFMC

1120 9) Develop specific recommendation to the CCC for subtheme 3.a

1220 Lunch break

10) **SUBTHEME 3.b: Building habitat condition in the stock assessment process and fishery management strategies**

1320 A. *Keynote Presentation: The Habitat Assessment Improvement Plan: Habitat data to enhance stock assessment*
Speaker: Thomas Noji, NMFS – Northeast Fisheries Science Center

1405 B. *Plenary Discussion: Building habitat condition in the stock assessment process and fishery management strategies*
Terms of Reference 3.b (Part 1) and Trigger Question Set 3.b (Part 1)
Session Facilitator: Meisha Key, SSC Chair PFMC
Rapporteurs: Becky Walker, WPFMC; Dave Witherell, NPFMC

1505 Afternoon break

1410 C. *Keynote Presentation: Aspects of Habitat of Particular Concern for fish population dynamics and fishery management*
Speaker: John Manderson, NMFS – Northeast Fisheries Science Center

1455 D. *Plenary Discussion: Building habitat condition in the stock assessment process and fishery management strategies*
Terms of Reference 3.b (Part 2) and Trigger Question Set 3.b (Part 2)
Session Facilitator: Samuel Pooley
Rapporteurs: Chris Hawkins, WPFMC; Steven Atran, GMFMC

1555 11) Develop specific recommendation to the CCC for subtheme 3.b

1655 Closing remarks . . . . . Charles Daxboeck

1700 Adjourn

Appendix II

Terms of Reference and Trigger Questions

Terms of Reference

Subtheme 1.a: ABC specification for data-limited and model-resistant stocks

i. Develop recommendations for quantifying uncertainty and translating those uncertainties into risk, particularly for data-poor stocks;

ii. Learn from different regions on how they dealt with data-limited and model-resistant stocks;

iii. Develop a framework for addressing ABC specification for data-limited and model-resistant stocks;

iv. Determine mechanism to coordinate state and federal policies for ACL-based management.

Subtheme 1.b: Implementation of National Standard 2 in the face of uncertainties

i. Gather inputs from the SSCs on the regional differences in the process for determining "best scientific information available";

ii. Provide recommendations on how each Council can comply with revised National Standard 2 (NS2) guidelines particularly for data-poor situations;

iii. Compile regional best practices in dealing with NS2 in ABC specification and respective Stock Assessment Reviews.

Subtheme 2: Evaluating existing ABC control rules: issues, challenges and solutions

i. Review the performance of each council's ABC control rules. Identify issues and challenges that confronted the SSCs in making an ABC specification and highlight the process used to solve issues;

ii. Develop evaluation and monitoring standards to assess the performance of the control rules in managing the stocks;

iii. Describe how each region intends to improve the existing ABC control rules to minimize uncertainties;

iv. Explore the advantages and disadvantages of explicitly and/or implicitly accounting for uncertainties when specifying ABCs;

v. Discuss ways to translate uncertainties into risk assessment and risk management as related to fishery management objectives.

Subtheme 3.a (Part 1): Incorporating ecological, environmental and climate variability in stock assessment and ecosystem based fishery management

i. From the discussion, document potential impacts of ecological and climate variabilities on FMP managed stocks. Describe historical changes in the fishery as affected by ecological and climate variabilities;

ii. Develop recommendation on priority research and data collection to address data needs to incorporate climate and ecosystem variabilities in assessments and fishery management strategies;

iii. Develop the terms of reference for incorporating ecological and climatic variability in stock assessments and fishery management approaches.

Subtheme 3.a (Part 2)**: Incorporating ecological, environmental and climatic considerations in stock assessments and ecosystem based fishery management**

i. Enumerate areas for inter-council collaboration addressing shifting stock distribution; Document the process and lessons learned from regions implementing an inter-council collaboration;

ii. Describe practical and viable management targets in light of uncertainties surrounding climate change;

iii. Discuss a process to quantify risks from climate and ecosystem uncertainties and apply them in fishery management strategies.

Subtheme 3.b (Part 1)**: Building habitat condition in stock assessments and fishery management strategies**

i. Compile regional strategies to incorporate habitat considerations in assessments and fishery management strategies

ii. Discuss how habitat conditions affect productivity and how these are considered in fishery management

Subtheme 3.b (Part 2)**: Building habitat condition in fishery management strategies**

i. Discuss and document lessons learned on how other Councils delineate EFH and HAPCs for the different fisheries;

ii. Discern process to incorporate EFH and HAPCs into fishery management strategies beyond the current use of federal consultation

Trigger Questions

Subtheme 1.a: ABC specification for data-limited and model-resistant stocks

i. What are the best practices used in grouping management unit species into species complexes in each region and what methods are used to determine OFL and ABCs?

ii. How can we use socioeconomic information in lieu of /or in combination with biological information in the OFL-ACL continuum, especially in data-limited situations?

iii. What are the various risk policies in place for data-poor stocks?

iv. How each SSC account for state fishery management in ABC specification/ACL-based management?

Subtheme 1.b: Implementation of National Standard 2 in the face of uncertainties

i. Are there examples of the 302(g)(1)(e) peer review process where it serves both NMFS and Councils in determining best scientific information available?

ii. Are the only available data the best available data?

iii. What are the best practices in each region for determining what the best scientific information available is?

Subtheme 2: Evaluating existing ABC control rules: issues, challenges and solutions

i. How are sources of uncertainties accounted for in your respective ABC specifications?

ii. What are the lessons learned from the previous ABC specification? (Problems and innovative solutions)

iii. What are the various risk policies developed by each council?

iv. How can the councils take advantage of the Management Strategy Evaluation approach to evaluate the performance of the existing control rules?

Subtheme 3.a (Part 1)**: Evaluating existing ABC control rules: issues, challenges and solutions**

i. How do you integrate ecosystem end-to-end models into a stock assessment/fishery management strategy and tactic?

ii. How can fishery management strategies adapt to changing ecosystems? How do you attribute the current stock status to the existing management framework versus ecosystem changes?

iii. How did other SSCs develop their ecosystem level reference points? Or what are they currently doing to develop those? What are the appropriate the ecosystem level reference points?

Subtheme 3.a (Part 2)**: Incorporating ecological, environmental and climatic considerations in stock assessments and ecosystem based fishery management**

i. How can SSCs in adjacent regions collaborate on managing stocks that shifted spatial distribution due to climate driven forcings?

ii. Should the fishery management objective be to manage based on the current state of the fishery or should the objective be to rebuild the stock to a near pristine level, especially considering the current impacts of climatic variabilities?

Subtheme 3.b (Part 1)**: Building habitat consideration in stock assessment and fishery management strategies**

i. How important are habitat considerations incorporated into fishery management strategies?

ii. What fishery management strategies incorporate habitat considerations?

iii. What process did your council undertake to incorporate habitat considerations into fishery management strategies?

iv. How does habitat condition affect estimates of productivity in assessments or fishery management strategies?

Subtheme 3.b (Part 2)**: Building habitat condition in fishery management strategies**

i. How does each SSC/Council define "essential" for Essential Fish Habitat?

ii. How does each SSC/Council define "ecological function", "sensitivity", "susceptibility", and "rarity" of Habitat Areas of Particular Concern?

iii. How does each Council utilize the 4 levels described in the MSRA EFH implementation regulations (50 C.F.R. §600.815(a)(1)(iii)) in designating the management unit species? To what extent are these applied?

iv. How is EFH used as a fishery management tool?

v. How does each SSC link/integrate habitat quality information with fishery productivity and incorporate such relationships in fishery management decisions?

vi. How can the state/condition of the habitat determine the need to make significant EFH/HAPC consultation suggestions

Appendix III
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