



ASIA-PACIFIC NETWORK FOR  
GLOBAL CHANGE RESEARCH

Final Technical Report  
CBA2017-06SY-Hofmann

IMBER IMBIZO V workshop: “Management Strategy Evaluation: Achieving  
Transparency in Natural Resource Management by Quantitatively Bridging Social  
and Natural Science Uncertainties”

The following collaborators worked on this project:

1. Heather Benway, Woods Hole Oceanographic Institution, USA, hbenway@whoi.edu
2. Leo Dutra, University of the South Pacific, Fiji, leo.dutra@csiro.au
3. Anes Dwi Jayanti, Universitas Gadjah Mada, Indonesia, anes.dwijayanti@ugm.ac.id
4. Julie Hall, NIWA, New Zealand, julie.hall@niwa.co.nz
5. Eileen Hofmann, Old Dominion University, USA, hofmann@ccpo.odu.edu
6. Shuya Nakatsuka, National Research Institute of Far Seas Fisheries, Japan, snakatsuka@affrc.go.jp
7. Xiujian Shan, Yellow Sea Fisheries Research Institute, China, shanxj@ysfri.ac.cn
8. Ingrid van Putten, CSIRO, Australia, Ingrid.vanputten@csiro.au
9. Francisco Werner, NOAA, USA, cisco.werner@noaa.gov

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# Table of Contents

Table of Contents .....	1
Project Overview .....	2
1. Introduction.....	6
2. Methodology .....	8
3. Results & Discussion .....	9
4. Conclusions.....	11
5. Future Directions.....	11
6. Appendices.....	12

## Project Overview

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<b>Project Duration</b>	: One year: 1 August 2017 – 31 July 2018
<b>Funding Awarded</b>	: US\$ 25,000 for Year 1
<b>Key organisations involved</b>	: <ol style="list-style-type: none"><li>1. Old Dominion University, USA, Eileen Hofmann</li><li>2. Commonwealth Scientific and Industrial Research Organisation, Australia, Ingrid van Putten</li><li>3. National Oceanic and Atmospheric Administration, USA, Francisco Werner</li><li>4. National Research Institute of Far Seas Fisheries, Japan, Shuya Nakatsuka</li><li>5. National Institute of Water and Atmospheric Research, New Zealand, Julie Hall</li><li>6. Yellow Sea Fisheries Research Institute, China, Xiujuan Shan</li><li>7. Unviversitas Gadjah Mada, Indonesia, Anes Dwi Jayanti</li><li>8. Woods Hole Oceanographic Institution, USA, Heather Benway</li><li>9. Integrated Marine Biosphere Research Project, Norway, Lisa Maddison</li><li>10. University of the South Pacific, Fiji, Leo Dutra</li></ol>

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### Project Summary

Management Strategy Evaluation (MSE) is a modelling tool used to evaluate sufficiently realistic simulations of potential policy choices in complex systems. As a contribution to the Integrated Marine Biosphere Research (IMBeR) project IMBIZO V, which occurred in October 2017, a workshop was convened with the goal of developing a coherent understanding of best practice approaches to MSEs. MSEs are becoming standard approaches to characterising risk across fisheries management organisations globally. The MSE workshop considered case studies drawn from different fisheries, with associated cultural, societal, and management characteristics (including small and large scale fisheries in the Asia-Pacific region) to better define best-practice principles of MSE development, implementation, and communication. MSEs are important tools that aid in delineating objectives, costs, and constraints that define risk and provide a possible mechanism to meet assessment challenges. Early career APN scientists and students were introduced to details of MSE development and implementation, and to colleagues who are part of professional networks that provide the necessary tools to fully participate in decision-making processes regarding marine resources. Networking and capacity building in MSE expertise in the APN region represent long-term impacts from the workshop.

**Keywords:** Management strategy evaluation; capacity development; marine systems; social sciences

## Project outputs and outcomes

### *Project outputs:*

The anticipated project outputs are: 1) synthesis papers of MSE application and best practices, 2) development of a community of researchers focused on MSE development and implementation, and 3) engagement of early career researchers in MSE application. As indicated in the following sections, the MSE workshop resulted in progress on each output. Progress on the project outputs and outcomes is continuing post IMBIZO V.

### *Project outcomes:*

- A. **Improved Understanding.** At the MSE workshop, presentations from across the world outlined regions and fisheries where MSEs have been implemented. The narrow geographic spread of these MSEs highlighted several discussion issues associated with implementing MSEs in countries with Small-Scale Fisheries (SSFs) where to date MSEs have not been implemented frequently. In these SSFs, data issues are extant and the highly quantitative nature of MSE means that there are many issues associated with applying MSE in these regions. The workshop provided better understanding of the issues relevant to SSFs and SSF characteristics that determine the appropriateness and feasibility of undertaking MSEs. The highlighted issues have led to ongoing discussions among SSF researchers, and scientists resident in countries where SSFs are extant, on the need for, and potential investment in, future MSE exercises.
- B. **Wider Participation.** Participation in the MSE workshop facilitated involvement by a growing number of researchers in the MSE community. Although not directly linked to, or based on workshop discussions, a special issue on MSEs and related research is being prepared for *Fisheries Research*. Planning for this special issue has benefitted from this expanded community. A greater number of researchers and guest editors were accessible and available as a result of the MSE workshop.
- C. **Early Career Opportunities.** The MSE workshop provided opportunities for the early career researcher participants. Contacts made at the MSE workshop provide new collaborations with institutes and people who can provide help and input for their research projects and general guidance on development of research projects. For some others, Ph.D. opportunities for co-supervision of research have developed. An important outcome is inclusion of MSE workshop participants as members of international committees, such as the IMBeR Interdisciplinary Marine Early Career Network (IMECaN) and the Human Dimensions Working Group (HDWG). An important opportunity arising from the MSE workshop is that Dr. Samiya Selim, an early career researcher supported by APN, has been invited to give a keynote plenary address at the IMBeR Open Science Conference that will take place in Brest, France, 17-21 June 2019.
- D. **Learning Opportunities.** Although not directly linked to the IMBeR MSE workshop, participants have applied their learning at other venues and interactions, such as a webinar that was held following the workshop:  
[https://www.st.nmfs.noaa.gov/Assets/quest/documents/QUEST\\_webinar\\_MSE.pdf](https://www.st.nmfs.noaa.gov/Assets/quest/documents/QUEST_webinar_MSE.pdf).

All MSE workshop participants were provided with access to a Toy MSE model for training and research purposes:

<https://puntapps.shinyapps.io/tunamse/>.

## Key facts/figures

- A total of 106 participants attended IMBIZO V. Graduate students (20 total) and postdoctoral scholars or early career researchers (31 total, less than six years post Ph.D.) represented 48% of the participants (Figure 1).
- Thirty-seven people attended the MSE workshop (see Appendix 1 for participant list). Of these, 8 were students and 9 were postdoctoral scholars or early career researchers, representing 46% of the total participants.
- The workshop attracted several prominent MSE experts including André Punt (USA), Ana Parma (Argentina), Jason Link (USA) and Gavin Faye (USA).



Figure 1. Participants at IMBeR IMBIZO V, Woods Hole Oceanographic Institution, Woods Hole, MA, USA, 2-5 October 2017.

## Potential for further work

The MSE workshop identified four areas for further development. A priority publication to be developed addresses the applicability of a MSE to SSFs, which is being led by an APN-funded attendee from Indonesia, Anes Dwi Jayanti. This publication will identify common traits between SSFs and develop a MSE process that can be applied to data poor situations, such as SSFs.

A second publication is focused on developing a typology that provides guidance on when a MSE is needed (or not) and is being led by Dr. Ingrid van Putten (CSIRO, Hobart, Australia) and Dr. Carla Sbrocchi (University of Technology, Sydney, Australia). A related third publication, led by Dr. Ingrid van Putten, is focused on identifying the core components of the MSE process, including the operation model.

An important effort from the MSE workshop is directed at connecting scientists through a clearing house for MSE information and computer code. This networking effort is led by

MSE workshop participants, Dr. Isaac Kaplan (NOAA Northwest Fisheries Science Center, USA) and Dr. Carla Sbrocchi (University of Technology, Sydney, Australia).

### **Publications (see Appendix 5 for full list of workshop-relevant links)**

The keynote presentation from the MSE Workshop, which was given by Professor André Punt, is available at:

<https://www.youtube.com/playlist?list=PLdGczf8u6mleqy1Tq8LOEnbQFTK53LMGT>.

This link also provides the keynote presentations for the other two IMBIZO V workshops and the IMBIZO V Opening Address by Professor Carol Robinson, IMBeR Chair.

The Toy MSE model used as a training exercise for the MSE workshop is available at:

<https://puntapps.shinyapps.io/tunamse>.

IMBeR News report summarizing IMBIZO V is available at:

<http://www.imber.info/news/imbizo-5-from-very-local-case-studies-to-global-marine-policy>.

### **Awards and honours**

Nothing to report.

### **Pull quote**

**Professor Carol Robinson, IMBeR Chair:** “From IMBeR’s perspective, the Management Strategy Evaluation workshop at IMBIZO V was a significant milestone in progressing the third Grand Challenge within our Science Plan. Specifically, the workshop addressed two IMBeR research questions: ‘How can IMBeR science best contribute to understanding management and governance trade-offs and use this for climate change adaptation and mitigation?’ and ‘How can IMBeR science contribute to the development of adaptation pathways and build adaptive capacity to deal with the consequences of marine global change?’. The workshop enabled IMBeR to grow its international network of social and natural scientists, particularly in the Asia-Pacific region. An important output from the workshop will be the synthesis paper discussing the implementation of MSEs throughout the world, and particularly in countries with SSFs. Without the APN funding, the global representativeness of the discussions at the workshop would have been much reduced, and IMBeR would not have achieved the extent of global inclusivity which we aspire to and pride ourselves upon.”

### **Acknowledgments**

#### **Collaborating Institutions:**

IMBeR International Project Office, Institute of Marine Research, Bergen, Norway  
Ocean Carbon Biogeochemistry (OCB) Office, Woods Hole Oceanographic Institution (WHOI), Woods Hole, MA USA

#### **Organising committee:**

Lisa Maddison, IMBeR, Bergen, Norway  
Veslemøy Kjersti Villanger, IMBeR, Bergen, Norway  
Fang Zuo, IMBeR, Shanghai, China

Heather Benway, OCB Office, WHOI, Woods Hole, MA, USA  
Mary Zawoysky, OCB Office, WHOI, Woods Hole, MA, USA  
Mai Maheigan, OCB Office, WHOI, Woods Hole, MA, USA

**Scientific Steering Committee:**

Carol Robinson (Chair) University of East Anglia, Norwich, UK  
Eileen Hofmann, Old Dominion University, Norfolk, VA, USA  
Julie Hall, NIWA, Wellington, New Zealand  
Alistair Hobday (IMBIZO V Co-Convener), CSIRO, Hobart, Australia  
Marion Glaser (IMBIZO V Co-Convener), ZMT, Bremen, Germany  
Laurent Bopp (Workshop 1 Convener), LSCE, Saint-Aubin, France  
Eric Galbraith (Workshop 1 Convener), Universitat Autònoma de Barcelona, Spain  
Gerhard Herndl (Workshop 2 Convener), University of Vienna, Vienna, Austria  
Tatiana Rynearson (Workshop 2 Convener), URI, Narragansett, RI, USA  
Gavin Fay (Workshop 3 Convener), University of Massachusetts, Dartmouth, MA, USA  
Ingrid van Putten (Workshop 3 Convener), CSIRO and University of Tasmania, Australia  
Cisco Werner (Workshop 3 Convener), NOAA Fisheries, Washington DC, USA

**Sponsors (see Appendix 2 for funding contributions):**

Asia-Pacific Network  
Institute of Marine Research (IMR), Bergen, Norway  
Korea Institute of Ocean Science and Technology (KIOST)  
East China Normal University, Shanghai, China  
North Pacific Marine Science Organization (PICES)  
Ocean Carbon and Biogeochemistry Program  
Scientific Committee on Oceanic Research  
National Oceanic and Atmospheric Administration

## **1. Introduction**

Marine and human systems are complex, which makes describing their interactions and potential outcomes difficult. Climate change and environmental variability impacts and their often obscured links add to the complexity of developing management strategies for marine resource use. The Ecosystems Approach to Fisheries adopted by the FAO Committee on Fisheries defines Management Strategy Evaluation (MSE) as a modelling-based approach aimed at testing the robustness of possible management arrangements (plans) by examining sets of decision rules, such as those used to adjust total allowable catch or effort controls, to determine which perform best in achieving the management objectives for a fishery. The MSE is designed to simulate physical, biological, management, and societal systems such that their effects on policy goals and societal objectives can be measured. As a result, the modelling tool provided by the MSE approach allows evaluation of sufficiently realistic simulations of potential policy choices in complex systems and assessment of the robustness of a particular management plan to uncertainties.

The Science Plan and Implementation Strategy that guides the Integrated Marine Biosphere Research (IMBeR) project is based around three Grand Challenges that consider the state and variability of marine systems, predictions and projections of ocean-human systems at multiple scales, and achieving sustainable governance and improving the science-policy-



society interface. The IMBeR IMBIZOs (Zulu word for ‘a gathering’) are an important activity for addressing the IMBeR Grand Challenges, facilitating transdisciplinary research, and providing assessments of current understanding and future research needs. IMBIZO V was developed around the theme of “*Marine biosphere research for a sustainable ocean: Linking ecosystems, future states and resource management*”. This IMBIZO took place from 2-5 October 2017, at Woods Hole Oceanographic Institution (WHOI), Woods Hole, MA USA, and was co-convened jointly with the Ocean Carbon Biogeochemistry (OCB) program. The IMBIZO V structure consisted of three concurrent workshops, each of which focused on aspects of the IMBeR Grand Challenges. The workshop on, “*Management Strategy Evaluation: Achieving Transparency in Natural Resource Management by Quantitatively Bridging Social and Natural Science Uncertainties*”, was designed to address science-policy issues regarding the management of marine resources and to provide syntheses and directions for future research, which incorporates aspects of the three Grand Challenges (see Appendix 1 for workshop programme). Also, the MSE workshop was relevant to the OCB current priority of understanding climate- and human-driven changes in ocean chemistry and associated impacts on biogeochemical cycles and marine ecosystems.

The MSE workshop goal was to develop a coherent understanding of best practice approaches to MSEs and thus serve as a learning opportunity for all attendees. To this end, the MSE workshop considered case studies for different fisheries, cultural, and societal characteristics (including small and large scale fisheries in the Asia-Pacific region) to better define best-practice principles of MSE development, implementation, and communication. Discussions at the workshop included development of potential future training and courses to ensure longevity of the workshop results and syntheses.

The MSE process provided five objectives for the workshop. The first objective was to determine the information from natural and social sciences that is essential for MSE development (e.g. the role of institutions). The second objective considered methods and modelling tools for MSE development, which is closely linked to the third objective that considered methods used to define societal management goals and needs (boundary conditions for the MSE.). The fourth objective was focused on approaches for MSE evaluation of management options, particularly generalizable approaches across cultural and social settings and fishery characteristics that define new and innovative approaches, leading to MSE best practices. The fifth objective was development of effective communication strategies to convey MSE predictions (and best-practice principles) to decision-makers. MSEs are becoming accepted approaches for characterising risk across fisheries management organisations globally. The MSE workshop was a first step in a longer-term effort to expand the use of MSEs in fisheries management.

Participation by early career scientists from the Asia-Pacific Network (APN) in the MSE workshop (see Appendix 3 for APN-sponsored early career scientist information) provided exposure to issues surrounding development and implementation of MSEs and the associated professional networks. As a result, they have a start at the tools that will allow them to fully participate in decision-making process regarding marine resources. Networking and capacity building in MSE expertise in the APN region represent long-term impacts from the workshop. Also, synthesis papers developed around selected MSE-related topics provide a tangible approach for capacity building because these will involve early career researchers and dissemination of the workshop results to the larger scientific community.

## 2. Methodology

The objectives of this project were addressed by a workshop on MSEs that took place over 3.5 days as a component of the IMBeR IMBIZO V. The workshop structure (see Appendix 1) consisted of a demonstration of a MSE model, invited workshop presentations, contributed workshop presentations, poster presentations, and breakout sessions. In addition, an invited plenary keynote presentation on the first day provided the current state-of-the-art and future directions for MSEs. The co-conveners for the MSE workshop, Ingrid van Putten, Franciso Werner, and Gavin Fay, have extensive experience with MSE development and implementation, fisheries management, and engagement of social science and stakeholders in policy development and decision support. They actively engaged with the workshop participants and provided insights and guidance on MSE development and implementation.

Aspects of all five objectives for the MSE workshop were addressed in the keynote plenary



Figure 2. Professor André Punt delivering the plenary keynote address for the MSE workshop.

presentation by Professor André Punt (Fig. 2), ‘*Management Strategy Evaluation (Current State and Challenges)*’. This presentation provided an overview of management issues for fisheries and examples of MSEs that have been applied to fisheries management. Key challenges for MSEs that include stakeholder involvement, appropriate objectives and communication of results were outlined which set the direction for discussions at the MSE workshop (Figure 3). The keynote presentation focused on uncertainties inherent in MSEs, which are

typically developed to evaluate management strategies for data-poor systems. Professor Punt also emphasized the need to learn from previous mistakes in management of fisheries and noted that a MSE provides the capability of evaluating options so that ‘history does not repeat itself’ (Figure 3).

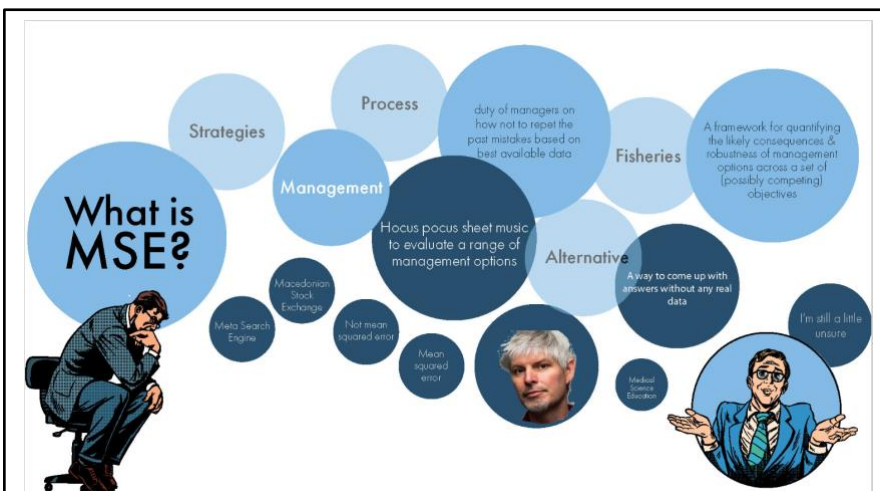


Figure 3. Infographic illustrating the points made by Dr. Punt in the MSE workshop keynote presentation. (credit: Indi Hodgson-Johnson)

Objectives 1, 2 and 3 were addressed by the invited MSE workshop presentation (Ana Parma, Argentina), ‘*Looking for robust harvest control rules: learning from MSE applications to specific fisheries*’, which focused on design and implementation of approaches to

rebuild the stock of southern blue fin tuna. Similarly, a second invited workshop talk (Jason Link, USA), ‘*What good are MSEs when the oceans, and people that use and manage stuff in*

them, are so stinking uncertain?’, dealt with issues of uncertainty and application of MSEs. The ‘Toy MSE model presentation’ by Gavin Fay (USA, workshop 3 co-convenor) illustrated the natural and social science information needed for a MSE, the MSE as a tool, and the need for communication of results. The toy MSE application is developed for the tuna fishery. All workshop participants were given access to this model (<https://puntapps.shinyapps.io/tunamse>). The contributed talks for the MSE workshop dealt with all aspects of the five objectives. In addition, the afternoon of Day 2 was devoted to application of MSEs to SSFs, which included examples of several case studies.

The IMBIZO programme included a cross-cutting session that provided opportunities for the MSE workshop participants to interact with participants in the other two other workshops. This activity used the [KJ-Technique](#) process that enabled predetermined groups with different geographic and disciplinary backgrounds, to objectively establish priorities for various issues pertaining to the IMBeR Grand Challenges, for example:

1. How can we better represent physiological, ecological, and evolutionary organism responses to multiple stressors (natural and human-induced) in marine ecosystem models so as to present the key dynamics at relevant scales in ways which enable decision-makers?
2. How can we more effectively collaborate with the marine-oriented social sciences and humanities to employ social science data in collaboratively developed integrated models of social-ecological dynamics?
3. What are the most urgent needs with regard to translating results and predictions into acceptable, desirable, feasible strategies to adapt, manage and govern marine-human systems more sustainably?
4. What interdisciplinary understanding is needed to improve ecosystem models developed for multiple scales and systems to allow projection and prediction of future states and evaluation through scenario development?
5. Biodiversity and extinction risk.

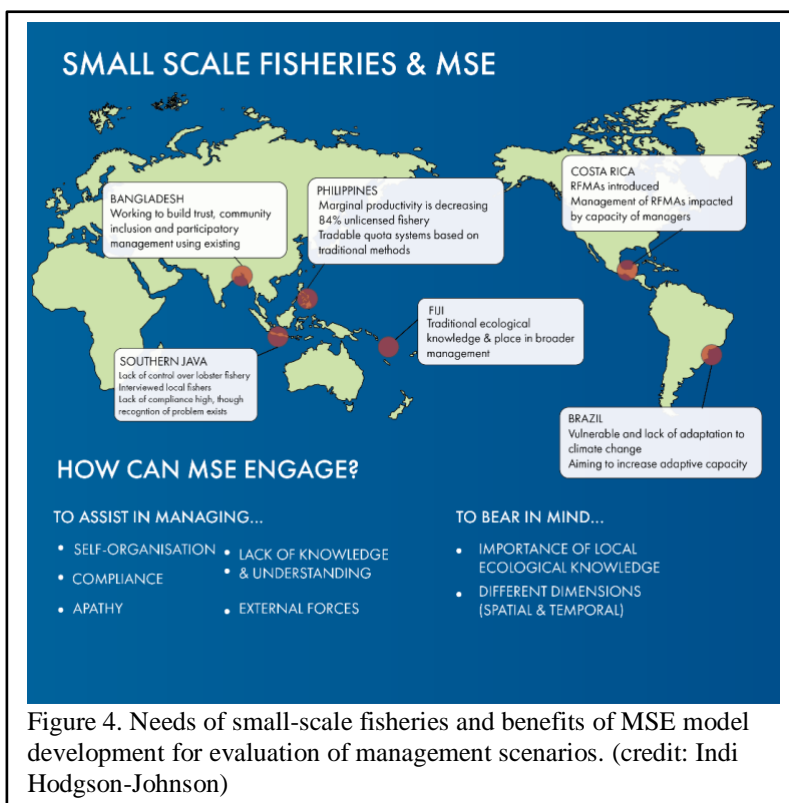


Figure 4. Needs of small-scale fisheries and benefits of MSE model development for evaluation of management scenarios. (credit: Indi Hodgson-Johnson)

### 3.Results & Discussion

A participant in IMBIZO V, Indi Hodgson-Johnson (University of Tasmania, Hobart, Australia) is a recognized expert in developing infographics that portray complex ideas to general audiences. Dr. Hodgson-Johnson attended the MSE workshop and her observations provided the basis for developing infographics that summarize the ideas and concepts that emerged from the workshop presentations and discussions. Many of the workshop presentations considered aspects of SSFs

and the application of MSEs to develop managements strategies for these systems. General themes that emerged from these discussions focused on barriers to MSE development and implementation. The engagement of communities in MSE use requires communities to self-organize and agree to develop compliance procedures for implementation of management strategies (Figure 4). Barriers to MSE engagement come from lack of knowledge and understanding, general apathy towards management policies and external factors, such as socio-economic and climate controls. The range of spatial and temporal scales that need to be considered in MSEs was recognised as well as its importance for data collections. Also, inclusion of local ecological knowledge was recognized as being critical to successful MSE implementation.

The requirements of the SSFs discussed at the workshop and the benefits of implementation of a MSE for management vary with the individual fishery. The summary infographic portrays these complexities and differences among these fisheries (Figure 4).

The MSE workshop highlighted issues associated with development and implementation of MSEs for a range of fisheries, the trade-offs that are faced for systems with limited data, the

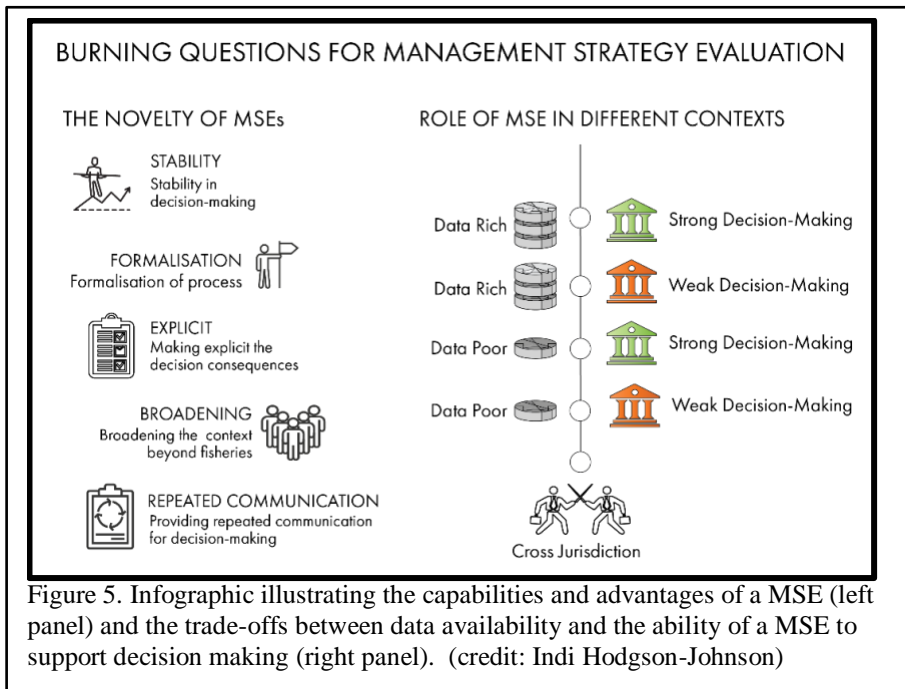


Figure 5. Infographic illustrating the capabilities and advantages of a MSE (left panel) and the trade-offs between data availability and the ability of a MSE to support decision making (right panel). (credit: Indi Hodgson-Johnson)

need robust decisions, and the tensions that exist between the communities that develop MSEs and those that implement MSEs. These discussions led to recognition of MSE capabilities and how these relate to data poor/data rich systems and decision support (Figure 5).

The MSE workshop

identified four areas for further development. A priority publication to be developed addresses the applicability of a MSE to SSFs, which is being led by Anes Dwi Jayanti. This publication will identify common traits between SSFs and MSE studies and develop a MSE process that can be applied to data poor situations, such as SSFs. A second publication is focused on developing a typology that provides guidance on when a MSE is needed (or not) and is being led by Dr. Carla Sbrocchi (University of Technology, Sydney, Australia). A related third publication, led by Dr. Ingrid van Putten, is focused on identifying the core components of the MSE process, including the operation model.

An important effort from the MSE workshop is directed at connecting scientists through a clearing house for MSE information and computer code. This networking effort is led by MSE workshop participants, Dr. Isaac Kaplan (NOAA Northwest Fisheries Science Center, USA) and Dr. Carla Sbrocchi (University of Technology, Sydney, Australia).

The quality of the MSE workshop presentations (see Appendix 6 for abstracts of workshop presentations) was overall excellent. The oral and poster presentations from the students and early career scientists were well prepared and well delivered. Even more impressive was the engagement by these researchers in discussions, question and answer sessions, and the cross-cutting activities.

The workshop successfully engaged participants in plenary discussions. However, the set-up of the room was not as conducive to inclusiveness as might have been if the tables and chairs could have been rearranged. The group was somewhat larger than ideal and a smaller size group may have been more beneficial. Break-out rooms for discussion sessions would have enabled greater interaction by all workshop participants. The presentations were well received and covered a broad range of issues, but time for questions after the talks was limited. More time for questions and discussion would have been beneficial.

#### **4. Conclusions**

Since the IMBIZO V workshop, the topic of MSE has gained more momentum - potentially motivated by the workshop. The objectives of the MSE workshop were successfully addressed. The students and early career researchers involved in the MSE workshop are now part of the IMBeR early career network, which will continue capacity building and development of a network of international collaborators. The topics introduced at the workshop are currently being built on in other venues and conferences.

We anticipate continued preparation and publication of papers from the MSE workshop, some of which are already in progress. We anticipate that the community of people who were involved in the workshop will continue to engage in MSE learning and have meetings around the world at different conferences. We also anticipate that the MSE community will keep growing and learning from each other and the experiences in different regions of the world.

By convening the workshop, we learned that there is a relatively large scientific knowledge gap and lack of implementation of MSE in SSFs. The workshop initiated interest in this topic to enable improved fisheries management in data poor SSFs. A community of practice should ideally be established on this topic in the future.

#### **5. Future Directions**

Topics identified for future development are: 1) publication that addresses the applicability of a MSE to SSFs, 2) development of a typology that provides guidance on when a MSE is needed (or not), 3) identification of the core components of the MSE process, including the operation model, and 4) connecting scientists through a clearing house for MSE information and computer code.

## Appendices

### Appendix 1. MSE Workshop Programme and Participant List.

**IMBIZO V, Management Strategy Evaluation Workshop Programme  
Woods Hole Oceanographic Institute, Woods Hole, MA, USA  
2-6 October 2017**

<b>Workshop: Management Strategy Evaluation: Achieving Transparency in Natural Resource Management by Quantitatively Bridging Social and Natural Science Uncertainties</b>		
<b>Day 1 Monday 2 October</b>		
<b>Time</b>	<b>Speaker</b>	<b>Title</b>
09:00-09:45	<b>Welcome to IMBIZO5!</b>	
09:45-10:30	<b>Eddie Allison</b>	<b>Keynote address for Critical Constraints workshop</b>
<i>10:30-11:00</i>	<i>Morning Tea</i>	
11:00-11:45	<b>Mary Ann Moran</b>	<b>Keynote address for Metabolic Diversity workshop</b>
12:00-12:45	<b>André Punt</b>	<b>Keynote address for MSE workshop</b>
<i>12:45-14:00</i>	<i>Lunch</i>	
14:00-15:30	WORKSHOP: Panel discussion (including demonstration of VES-V tool to visualize different scenarios)	
15:30-16:00	<i>Afternoon tea</i>	
16:00-17:00	WORKSHOP: Toy MSE model presentation	
17:00-20:00	<b>Poster session</b>	

<b>Day 2 Tuesday 3 October Morning</b>		
<b>Time</b>	<b>Speaker</b>	<b>Title</b>
09:00-10:00	WORKSHOP Continuation: Toy MSE model presentation and Question & Answer session	
<b>10:00-10:30</b>	<b>WORKSHOP: Invited Talks</b>	
5 min	Jason Link	What good are MSEs when the oceans, and people that use and manage stuff in them, are so stinking uncertain?
5 min	Ana Parma	Looking for robust harvest control rules: learning from MSE applications to specific fisheries
10:30-11:00	<i>Morning Tea</i>	
<b>11:00-12:00</b>	<b>WORKSHOP: Talks (natural science)</b>	
5 min	Cecilie Hansen	Dealing with ‘the boss’ in the Barents Sea – as easy as it sounds?
5 min	Ana Bevilacqua	Dealing with the discard ban issue: coupling methodologies in a MSE framework
5 min	Stephanie Brodie	Quantifying the utility of dynamic ocean management through management strategy evaluations
5 min	Gizem Akkuş	A comparative assessment of the Black Sea anchovy stock by using holistic production and analytical age structure models
5 min	Isaac Kaplan	Testing harvest control rules within end-to end ecosystem models: a stepping stone toward management strategy evaluation
5 min	Lisa Kerr	Modeling the implications of stock mixing and life history uncertainty of Atlantic bluefin tuna
5 min	Eileen Hofmann	Factors affecting distribution of the Atlantic surfclam ( <i>Spisula solidissima</i> ), a continental shelf biomass dominant, during a period of climate change
5 min	Robert Wildermuth	Developing a framework for evaluating structural uncertainty in social –ecological system models: a Bayesian network approach
5 min	Daniel Howell	REDUS MSE: a flexible Management Strategy Evaluation modelling tool
5 min	Zeyu Zeng	Effects of climate change and fishing on the Pearl River estuary ecosystem and fisheries
12:00-12:45	WORKSHOP: Discussion & writing activities	
12:45-14:00	<i>Lunch</i>	

<b>Day 2 Tuesday 3 October Afternoon</b>		
<b>14:00-15:00</b>	<b>WORKSHOP: Talks (small-scale fisheries)</b>	
10 min	Maria Rebecca Campos	Bioeconomic Modelling of Fisheries Conservation Policies in the Philippines
5 min	Ane Dwijayanti	Fishermen Social Rebound to Meet the Equilibrium in Fisheries Management: Study Case New Regulation on lobster fisheries in Southern Java, Indonesia
5 min	Samantha Williams	Finding synergy in conservation and small-scale fisheries: Case studies from the Western Cape, South Africa
5 min	Helven Naranjo-Madriral	A model-based approach for strengthening resilience of responsible marine fishing areas in Costa Rica
5 min	Nemillie Qaqara	Exploring Traditional Ecological Knowledge (TEK) marine resources use: a case study from two villages in Fiji
5 min	Ivan Martins	Factors of social vulnerability to climate change among small-scale fishing communities from the South Brazil Bight
5 min	Samiya Selim	Evidence of ecosystem based adaptation in coastal fisheries of Bangladesh
5 min	Dhanya Kandarattil	Fisheries and livelihood options of marginalized communities; in the scenario of changing climate, in Kerala, India
15:00-15:30	WORKSHOP: Discussion & writing activities	
15:30-16:00	<i>Afternoon tea</i>	
16:00-18:00	<b>Cross-workshop 'sticky note' activity</b>	

<b>Day 3 Wednesday 4 October Morning</b>		
<b>Time</b>	<b>Speaker</b>	<b>Title</b>
9:00 -10:00	<b>David VanderZwaag</b>	<b>Cross-workshop Keynote talk</b>
10:00-10:30	<i>Morning Tea</i>	
<b>10:30-12:00</b>	<b>WORKSHOP: Talks (human dimension)</b>	
10 min	Robert Scott	Developing harvest strategies for the western central Pacific tuna fishery



5 min	Per Arneberg	Marine ecosystems and social needs: The importance of merging social and natural science for servicing policy needs to the best for humans and nature
10 min	Sarah Gaichas	Getting on the same page, or at least in the same library: lessons in communication from a stakeholder driven MSE for Northeast US Atlantic herring
10 min	Julie Hall	How do we move to ecosystem-based management?
10 min	Derek Armitage	Integrating governance into management strategy evaluation
5 min	Carla Sbrocchi	Comparative analysis of wellbeing frameworks for multi-objective scenario development
5 min	Natasa Vaidianu	Emerging governance requirements: manage fish and people for a coherent and sustainable exploitation in the Romanian Black Sea
10 min	Prateep Nayak	Fishing for power: Conceptualization of social-ecological change and marginalization through local metaphors and political ecology narratives
5 min	Sara Miñarro	A new conceptual framework to evaluate drivers of fishing behavior in small scale fisheries
5 min	Katherine Mills	Climate adaptation in Northeast U.S. fisheries: eliciting and evaluating strategies of interest to stakeholders and communities
5 min	Kalpana Chaudhari	Bridging social and natural science uncertainties and changes in marine ecosystem: evaluating the impacts of climate change and management strategy evaluation using application of E-governance and ICTs
5 min	Gaku Ishimura	Optimizing fishing strategies and spatial management by linking spatial abundance information and economic indicators
12:00-12:45	WORKSHOP: Discussion & writing activities	
12:45-14:00	<i><b>Lunch</b></i>	

<b>Day 3</b> <b>Wednesday 4 October</b> <b>Afternoon</b>	
14:00-15:00	WORKSHOP: Discussion & writing activities
15:00-15:30	WORKSHOP: Talks (overflow from previous sessions)

15:30-16:00	<i>Afternoon tea</i>
16:00-17:00	<b>Debate</b>
After debate	<b>IMBIZO V dinner</b>

<b>Day 4 Thursday 5 October</b>		
<b>Time</b>	<b>Speaker</b>	<b>Title</b>
9:00-10:30	WORKSHOP: Discussion & writing activities	
<i>10:30-11:00</i>	<i>Morning Tea</i>	
11:00 -12:45	WORKSHOP: Discussion & writing activities	
<i>12:45-14:00</i>	<i>Lunch</i>	
14:00-15:00	<b>Summary from the workshops (Infographic and oral presentations)</b>	
15:00-15:30	<i>Closing ceremony</i>	

## **MSE Workshop Participants**

### **Akkuş, Gizem**

Middle East Technical University  
gizemakkuss@gmail.com

### **Armitage, Derek**

University of Waterloo  
derek.armitage@uwaterloo.ca

### **Arneberg, Per**

Institute of Marine Research  
per.arneberg@imr.no

### **Bevilacqua, Ana**

FEME/UFRN  
anahelena.bevilacqua@gmail.com

### **Brodie, Stephanie**

NOAA  
stephanie.brodie@noaa.gov

### **Campos, Maria Rebecca**

University of the Philippines Open University  
cmaribec@yahoo.com

### **Chaudhari, Kalpana**

ISDR, India  
isdrklc@hotmail.com

### **Dias, Bia**

UMass Amherst  
biadsdias@gmail.com

### **Dwijayanti, Anes**

Universities Gadjah Mada  
anes.dwijayanti@ugm.ac.id

### **Gaichas, Sarah**

NOAA Northeast Fisheries Science Center  
Sarah.Gaichas@noaa.gov

### **Hall, Julie**

NIWA  
julie.hall@niwa.co.nz

### **Hansen, Cecilie**

Institute of Marine Research  
cecilie.hansen@imr.no

### **Hofmann, Eileen**

Old Dominion University  
hofmann@ccpo.odu.edu

### **Howell, Daniel**

IMR  
daniel.howell@imr.no

### **Ishimura, Gaku**

Iwate University  
gakugaku@iwate-u.ac.jp

### **Kaplan, Isaac**

NOAA  
isaac.kaplan@noaa.gov

### **Kerr, Lisa**

Gulf of Maine Research Institute  
lkerr@gmri.org

### **Martins, Ivan**

Oceanographic Institute from University of  
São Paulo  
ivanmmartins@usp.br

### **Mills, Katherine**

Gulf of Maine Research Institute  
kmills@gmri.org

### **Miñarro, Sara**

Autonomous University of Barcelona  
sara.minarro@uab.cat

### **Naranjo-Madrigal, Helven**

ALNA S.A  
helvenn@hotmail.com

### **Nayak, Prateep**

University of Waterloo  
pnayak@uwaterloo.ca

### **Qaqara, Nemillie**

University of the South Pacific  
nemilyq464@gmail.com

### **Reid, Chris**

Pacific Island Forum Fisheries Agency  
chris.reid@ffa.int

### **Sbrocchi, Carla**

University of Technology, Sydney  
carla.d.sbrocchi@student.uts.edu.au

### **Scott, Robert**

Secretariat of the Pacific Community  
robertsc@spc.int

### **Selim, Samiya**

University of Liberal Arts, Bangladesh

samiya.selim@ulab.edu.bd

**Townsend, Howard**

NOAA

howard.townsend@noaa.gov

**Vaidianu, Natasa**

Ovidius University of Constanta/University of  
Bucharest

natasa.vaidianu@geo.unibuc.ro

**Wildermuth, Robert**

University of Massachusetts Dartmouth

rwildermuth@umassd.edu

**Zeng, Zeyu**

Sun Yat-Sen University

zengzy5@mail2.sysu.edu.cn

## Appendix 2. Funding Sources Outside the APN.

Organization/Agency	Amount
Scientific Committee on Oceanic Research	\$7,500
Ocean Carbon Biogeochemistry Program	\$1,000
Korea Institute of Science and Technology	\$3,300
National Oceanic and Atmospheric Administration	\$3,950
North Pacific Science Organisation (PICES)	\$1,350
Institute of Marine Research, Norway	\$500
Woods Hole Oceanographic Institute	\$3,500
	in kind contribution; venue and audio-visual equipment
East China Normal University, Shanghai	\$700
	in kind contribution; administrative support
Old Dominion University	in kind contribution; administrative support

## Appendix 3. List of Young Scientists.

**Samiya Selim**, University of Liberal Arts Bangladesh, Bangladesh, samiya.selim@ulab.edu.bd

*Involvement:* Participant in Workshop 3 on MSEs; gave presentation entitled, ‘*Evidence of ecosystem based adaptation in coastal fisheries of Bangladesh*’.

*Short message:*

*APN funding received:* Airfare: \$1500 Baggage: \$25 Hotel: \$556.17 Per diem: \$210 Bus: \$60 TOTAL: \$2351.17

*Short message:* At IMBIZO 5, I was able to successfully network with other natural and social scientists who are also working in this social-ecological domain of marine ecology and sustainability. I was able to share my own research on ecosystem-based adaptation in coastal Bangladesh and get feedback on how I can develop this research further. I was also able to connect with other early career scientists and discuss opportunities for joint paper publication. Part of my current work is focused on the Sustainable Development Goals and building partnership with research academics and civil societies so can start mobilizing research needed to meet the SDG targets in Bangladesh. One of my current functions is working on SDG 14 and I will now use the connections I have built at IMBIZO 5 to start international collaborations and building projects on sustainable aquaculture under the threats of climate change.

**Maria Rebecca Campos**, University of the Philippines Open University, Los Banos, Laguna, Philippines, mcamposc@upou.edu.ph

*Involvement:* Participant in Workshop 3 on MSEs; gave presentation entitled, ‘*Bioeconomic Modelling of Fisheries Conservation Policies in the Philippines*’.

*APN funding received:* Airfare: \$1500 Hotel: \$600 TOTAL: \$2100

*Short message:* I participated in Workshop 3 –Management Strategy Evaluation at IMBIZO V thanks to support from the APN. It was a venue for scientists and young researchers from all over the world to show the different approaches and methodologies used in modelling and in arriving at MSEs. It was a mix of natural and social scientists who later participated in a

debate on climate change, modelling, and decision making. What is significant is to establish the link between science and decision makers/policy makers in the light of different cultural, social and technological-fisheries factors. I will share the research papers and impressions in this conference at the University of the Philippines Open University and strengthen the bridge of research collaboration with researchers from other institutions involved in IMBIZO V.

**Anes Dwi Jayanti**, Gadjah Mada University, Indonesia, anes.dwijayanti@ugm.ac.id

*Involvement:* Participant in Workshop 3 on MSEs; gave presentation entitled, '*Fishermen Social Rebound to Meet the Equilibrium in Fisheries Management: Study Case New Regulation on lobster fisheries in Southern Java, Indonesia*'.

*APN funding received:* Airfare: \$1500 Hotel: \$600 Visa: \$160 Bus: \$60 TOTAL: \$2320

*Short message:* Being one of the participants in IMBIZO5 activities is a valuable opportunity for me personally as well as an institution representative. As an academic, researcher and community development activist, I not only need knowledge but also strong network and cooperation, especially in various but relevant fields because the problems encountered in the field is a problem that requires a broad understanding. This activity is a stepping-stone for me to see more critical issues, looking at solutions more creatively and strategically taking action. I never thought that scientific meetings would be so much fun as to know many disciplines that have a common interest in maintaining the sustainability of underwater resources, which I believe is one of the goals of the Sustainable Development Goal. Once again I am grateful and will not waste this opportunity in building my capacity as an academic, researcher, and activist in developing community capacity. And also as a representative of institutions to establish inter-institutional and inter-state cooperation so that the scientific aim can be supported by many organizations that share the same views on oceanographic issues and marine resources that are in the absence of sustainability issues. Being part of IMBIZO gives me the spirit to continue, to grow and share this experience so that more and more people are alert and aware of the global problems facing the world about the environment, where we live and the resources that support our sustainability. I would acknowledge APN (Asia-Pacific Network for Global Change Research), and IMBeR, thank you for giving me the opportunity to be part of IMBIZO5.

**Nemillie Qaqara**, University of the South Pacific, Fiji, nemilyq464@gmail.com

*Involvement:* Participant in Workshop 3 on MSEs; gave presentation entitled, '*Exploring Traditional Ecological Knowledge (TEK) marine resources use: a case study from two villages in Fiji*'.

*APN funding received:* Airfare: \$1500 Hotel: \$600 Visa: \$160 Bus: \$60 TOTAL: \$2320

*Short message:* My experience at the IMBIZO5 has been gratifying, for it allowed me to be part of the four most interesting and amazing days. Throughout this experience, I have really learned so much that is hard to start expressing my full thoughts. It was very interesting with the different years of experience between the panel leaders and participants. They all mention the importance of teamwork, the ability to listen to one another, and to respect each other's opinion. This was a revelation on how our society works together, and how each one of us can have use of one simple and important resource, communication. I enjoy communicating and meeting new people so this experience has only prepared me on becoming a better networker and researcher. I really enjoyed the sessions and learned key details in managing marine resources and learning from different perspectives and experiences. My gratitude goes to the sponsors (APN) and supporters who enabled me to have this experience of a lifetime for better broaden my career and understanding.

**Robert Scott**, Secretariat of the Pacific Community, Noumea, New Caledonia,  
robertsc@spc.int

*Involvement:* Participant in Workshop 3 on MSEs; gave presentation entitled, ‘*Developing Harvest Strategies for the Western Central Pacific Tuna Fishery*’.

*APN funding received:* Airfare: \$1500 Hotel: \$600 Per diem: \$210 Bus: \$60 TOTAL: \$2370

*Short message:* I very much enjoyed being part of the recent IMBIZO-5 at Woods Hole and hope that I will be able to attend similar future events. I currently work in the stock assessment team of the Oceanic Fisheries section of SPC. The section is relatively small and there are limited opportunities to interact with other scientists within our field and also more broadly. In this sense I particularly enjoyed the diverse mix of scientific interests and backgrounds at IMBIZO-5 and the opportunity to develop contacts with researchers working in similar fields. With specific reference to the MSE workshop, the presentations and discussions highlighted the range of approaches being taken in a variety of geographical regions and provided a good indication of how the work that I am personally involved in fits into the broader picture of development and experience in this field. I am extremely grateful to the Asia Pacific Network for supporting my attendance.

**Rajani Kanta Mishra**, National Centre for Antarctic and Ocean Research, India,  
rajanimishra@yahoo.com

*Involvement:* Participant in Workshop 2 and 3 on MSEs; gave presentation entitled, ‘*Phytoplankton Community Adaptation and Variability in Response to Different Environmental Conditions of Indian Ocean Sector of the Southern Ocean*’.

*APN funding received:* Per diem: \$210 Bus: \$60 TOTAL: \$270

*Short message:* I acknowledge gratefully for to APN for funding as support to attending IMBIZO5, October, 2017, WHOI, USA and also thanks to Lisa Maddison, organizing committee, IMBeR for arranging fund.

**Kalpna Chaudhari**, Institute for Sustainable Development & Research, India,  
isdrklc@hotmail.com

*Involvement:* Participant in Workshop 3 on MSEs; gave presentation entitled, ‘*Bridging social and natural science uncertainties and changes in marine ecosystem: evaluating the impacts of climate change and management strategy evaluation using application of E-governance and ICTs*’.

*APN funding received:* Airfare: \$1492.14 Hotel: \$586 Per diem: \$210 Bus: \$60 TOTAL: \$2348.14

*Short message:* IMBIZO5 was an immense and pioneer international congregation of ocean professionals and practitioners. The discussions and deliberations were academically stimulating and useful for the marine and coastal community. The IMBIZO was well planned and accommodated interdisciplinary and multidisciplinary scientists, researchers and professionals in ocean-related subjects and was full of showcase examples and case studies with a blend of knowledge and practice. I have followed the previous IMBIZOs and other IMBeR-related activities for several years. However, this year with the support of the Asia Pacific Network for Global Change Research, I got the opportunity to participate and present my work in this great ocean related assembly and meet experts and professions working in ocean science. This helped me to network for future association on continental joint programs on ocean, marine and coastal science. The fish stocks assessments and models and new research paradigm presented at the MSE workshop are indeed a pathfinder for an early career scientist and provided ample opportunity to learn and enhance skills and knowledge on ocean science.

**Mahammed Moniruzzaman**, University of Calcutta, India, moni.vbu@gmail.com  
*Involvement:* Participant in Workshop 1 and 3 on MSEs; gave presentation entitled, ‘*Consequence of Climate Stress on Commercial and Ecological Important Fish Species of Indian Sundarbans: Perspective from Metabolic and Reproductive Attributes and Future Prediction of Their Conservation Status*’.

*APN funding received:* Hotel: \$354 Per diem: \$210 Bus: \$60 TOTAL: \$624.00

*Short message:* My professional training during my postdoctoral study in last three years covered primarily focusing on climate shift and environmental stress on physiology and conservational status of estuarine fish. I believe my experience provides me an excellent basis to carry out further research in the global scenario. Joining as a participant in IMBIZO5 at Woods Hole helped me to present my work in front of world-famed scientists and provided me the opportunity to pursue my work further by learning various ways to solve critical problems regarding eco-physiological stress. This conference allowed the young scientists like me to network with other professionals and scientists in this academic world. I was able to take the pulse of what is happening globally and hear ideas I am not even aware of. I was also able to keep up with the recent literature and valuable data base regarding marine and costal research. Presentation of my work in such workshop increased its visibility and accessibility. Besides, I obtained valuable feedback on my research and share my research findings with others in my field. Meeting with others in my field led to new opportunities for collaborative efforts in future and made my work from regional to global. I also learnt what others in the field are doing and this can lead to new thoughts. This was a magnificent opportunity to grow as a researcher, collaborator and presenter.

**Anoop Das**, Centre for Conservation Ecology, MES Mampad College, Kerala, India, daksas@gmail.com

*Involvement:* Participant in Workshop 1 and Workshop 3 on MSEs; gave presentation entitled, ‘*The effect of climate change on seabird communities - A retrospection to past, present and future*’.

*APN funding received:* Airfare: \$1000 Hotel: \$600 Per diem: \$210 Bus: \$60 TOTAL: \$1870.00

*Short message:* IMBIZO5 is intended to express the programmatic developments in the field of ocean research. It also facilitated hands on training and brain-storming discussions with small groups of researchers from all over the world. The discussions and the contacts with other compatible people generated further chances of collaboration for my future research works. The information disseminated through the discussions would go a long way to facilitate the mitigation measures to climate change and also for taking up possible measures for the conservation of natural resources. This would also work towards the policy interventions in the respective countries. The IMBIZO5 has made a commendable change in my worldview and research outlook. I could attend because of the travel grant I was awarded from the Asia-Pacific Network for Global Change Research.

#### **Appendix 4. Glossary of Terms.**

<b>Acronym</b>	<b>Definition</b>
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FAO	Food and Agriculture Organization of the United Nations
IMBeR	Integrated Marine Biosphere Research Project
IMBIZO	Zulu word for ‘a gathering’
LSCE	Laboratory for Sciences of Climate and Environment



MSE	Management Strategy Evaluation
NIWA	National Institute of Water and Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
OCB	Ocean Carbon Biogeochemistry Program
SCOR	Scientific Committee on Oceanic Research
SSF	Small-scale fisheries
URI	University of Rhode Island
WHOI	Woods Hole Oceanographic Institution
ZMT	Leibniz Centre for Tropical Marine Research

## Appendix 5. Links to IMBIZO V Information.

- [IMBIZO V website link](#)
- [Video recordings of the keynote presentations from IMBIZO V](#)
- [IMBIZO V poster](#)

## Appendix 6. Abstracts of MSE Workshop Presentations.

LOOKING FOR ROBUST HARVEST CONTROL RULES: LEARNING FROM MSE APPLICATIONS TO SPECIFIC FISHERIES

Parma A.M.

Increasing recognition of the wide uncertainty that surrounds fisheries assessments has prompted a change in the science used to formulate management advice. While initially the focus of policy analysis was on optimality, the emphasis has shifted first to risk avoidance, and more recently to achieving robustness in the face of uncertainty. Experience has shown time and again that the use of a “best-assessment” approach, i.e. a best estimate of the absolute exploitable biomass coupled with a function that specifies the target fishing mortality, can fail to achieve the desired robustness and lead to unnecessary disruptions in the conduct of fisheries. The most important selling point for MSE is that it allows quantification of the performance of management procedures in advance of implementation, so that their robustness in the face of alternative future scenarios can be evaluated. In addition, unresolvable arguments about which model is best to represent past and future system dynamics can give way to more productive discussions about the scenarios to include as operating models for MSE. These important benefits are well illustrated by the process of designing and implementing a strategy for rebuilding the stock of southern bluefin tuna (SBT). Not only did the MSE approach allow progress away from stagnation in the scientific process, but it delivered a strategy that in practice proved to be robust to appreciable changes in the best assessments of absolute stock size. Relatively simple management procedures, like the one adopted for SBT, that work by adjusting allowable catches up or down in response to trends in stock size indicators may, in general, afford higher robustness to changes in the scale of abundance estimates than the standard best-assessment approach.

### Invited Talk

INTEGRATING GOVERNANCE INTO MANAGEMENT STRATEGY EVALUATION

Armitage D., Davies I., Francis T., Levin P., Okamoto D., Punt A., Silver J.

Our aim in this paper is to examine if and how governance issues can be effectively integrated into formal management strategy evaluation (MSE). Governance refers to the broader processes and institutions (e.g., regulatory/top-down, community-based or collaborative) through which societies make decisions that affect the environment and natural resources. Governance arrangements and processes exert a significant influence on how management objectives are defined, the effectiveness and implementation of management decisions (e.g., total allowable catch or effort control), information included in evaluations, and assessments of management outcomes. Despite its influence, however, there is limited explicit consideration of governance in MSE, and this may undermine efforts to develop realistic simulations of particular management plans and their trade-offs. In this paper, we 1) outline and define key attributes of governance that can influence MSE (e.g., role of different knowledge systems, perceptions of legitimacy, flexibility and adaptiveness); 2) examine how these attributes can manifest differently depending on the model of governance (e.g., top-down vs. collaborative), with implications for compliance (e.g., with harvest control rules); and 3) reflect on the influence of governance at various stages in an MSE where decisions are made and behaviors may change in ways that influence simulation modelling. This paper is one outcome of the Ocean Modelling Forum which aims to improve the way models are used to address the most pressing challenges facing the world's oceans.

Oral presentation

#### MARINE ECOSYSTEMS AND SOCIAL NEEDS: THE IMPORTANCE OF MERGING SOCIAL AND NATURAL SCIENCE FOR SERVICING POLICY NEEDS TO THE BEST FOR HUMANS AND NATURE

van der Meeren G.I., Arneberg P.

The oceans and seas are of vital importance for nature and human life but face multiple challenges including climate change, overfishing. Norwegian marine management plans are since 2012 in place to provide a framework for the sustainable use of resources and ecosystem services and at the same time maintain the structure, functions, productivity and diversity of the areas ecosystems. Yet, still missing is a way to include socio-ecological research to service policy needs. Based on what researchers know, stakeholders with different interests need more knowledge to achieve sufficient understanding to make well-informed decisions. It is equally important for scientists to understand what is important for the stakeholders. This gap has not been bridged. The issues to be challenged to mend this gap are known. The main challenge is to remove the cultural differences between social and natural science to open for true integrated research as well as actual holistic management, based on fully integrated marine strategy evaluation.

Oral presentation

#### DEALING WITH THE DISCARD BAN ISSUE: COUPLING METHODOLOGIES IN A MSE FRAMEWORK

Bevilacqua A.H.V., Pennino M.G., Coll M., Bellido J.M.

Discards are one of the most important topics in fisheries management, both for economic and ecological aspects. The Common Fisheries Policy plan proposed by the European Commission for 2014-2019 presents a controversial goal: to enforce the landing of fishing discards as a measure to promote their reduction. This political decision will shape the future of the fishing exploitation in European Seas with socio-economical implications in the short term. For these reasons, both stakeholders and policy makers are now claiming for more effective tools that can be used to support the decision-making framework. Within this context, the management strategy evaluation (MSE) can be a decisive tool to identify a best management action among a set of different scenarios under the discard ban application. In the present study we implemented a MSE approach coupling hierarchical Bayesian spatial models (HBSM) with the Ecopath with Ecosim (EwE) food web ones, exploring different future developments in the North Western Mediterranean Sea under the landing obligation. In particular, we firstly assessed high density discard areas using HBSM with discard and environmental data, and secondly, we simulated possible spatial closures in the identified areas using Ewe. We discuss the socio-economical implications of each one of the simulated cases and we argue that a combination of fishery management measures will be a more effective global strategy to deal with this important issue.

Oral presentation

#### QUANTIFYING THE UTILITY OF DYNAMIC OCEAN MANAGEMENT THROUGH MANAGEMENT STRATEGY EVALUATIONS

Brodie S., Welch H., Hazen E., Scales K., Jacox M., Briscoe D., Maxwell S., Crowder L., Lewison R., Bograd S.

Spatiotemporal management strategies are often implemented at overly coarse scales that do not consider the physical and biological dynamics inherent in ocean ecosystems. Dynamic Ocean Management (DOM) is a strategy that rapidly changes in space and time in response to changes in the ocean and its users. DOM has theoretically been shown to increase the efficiency and efficacy of fisheries management, but there is a need to empirically quantify the benefits of DOM compared to static strategies. This quantification can be achieved using an MSE framework. We review the benefits and drawbacks of existing MSE tools (e.g. Marxan, SeaSketch, EcoSpace), and describe how DOM applications can act as a complementary tool for examining the utility of spatial management strategies. To showcase this, we used a case study from the California Drift Gillnet (DGN) fishery which has a number of static spatial management closures. A bycatch reduction tool, named EcoCast, has been developed for this fishery and provides real-time habitat maps of target and bycatch species. Here, EcoCast was used as an operating model to test the utility of DOM as a spatial management approach. This was done using a hindcast analysis of the predicted distribution and observed catch of three bycatch species (leatherback turtle, sea lion, blue shark) and one target species (swordfish). We explored four MSE performance measures: bycatch reduction, reduction in landings, efficiency of bycatch reduction, and the spatiotemporal efficiency of existing closures. The existing DGN seasonal closures are effective in encompassing the predicted habitat distribution of bycatch species. But under anomalous conditions, the boundaries of spatial closures could be reduced or expanded to satisfy competing objectives of bycatch reduction and economic viability of the fishery. Our work

highlights that dynamic ocean management strategies can help achieve conservation targets, support economic viability, and sustain social sustainability.

Oral presentation

#### BIOECONOMIC MODELLING OF FISHERIES CONSERVATION POLICIES IN THE PHILIPPINES

Campos M.R.

The Philippines is surrounded with many fishing grounds. In spite of this, most fishermen in the area live in poverty, and their plight is getting worse, not better. Current fisheries policies for the area have failed to improve the situation but no research has been done to find out why. This report uses a bioeconomic model to simulate the effects of changes in the enforcement levels of current policies. Investments of the government on different levels of enforcement were assessed using benefit cost analysis. The report assesses the effects of enforcing current fisheries policies more stringently. The situation would be transformed into one in which large and perhaps increasing numbers of people would continue to fish, expending larger amounts of effort to comply with various gear restrictions but, in all likelihood, harvesting no fewer fish. Because the bay is already overfished, catch per unit effort and marginal productivity would decrease. Any additional fishing effort in the bay will result in a decrease in the average catch of all fishermen. Enforcement of current policies will not address the underlying problems of open access and the overfishing it leads to. One policy to deal with the problems of open access and overfishing is to set a limit on the total number of fish that can be caught and divide this quota among Lamon Bay's fishermen.

Oral presentation

#### BRIDGING SOCIAL AND NATURAL SCIENCE UNCERTAINTIES AND CHANGES IN MARINE ECOSYSTEM : EVALUATING THE IMPACTS OF CLIMATE CHANGE AND MANAGEMENT STRATEGY EVALUATION USING APPLICATION OF E- GOVERNANCE AND ICTS

Chaudhari K.L., Philip P.J.

Marine and human systems are complex in the Ocean Management System. The impacts of climate change and environment variability are dynamics on the coastal society. The empowerment of coastal communities is crucial for the development of the marine resources. Bringing the coastal population in to the mainstream of the digital technologies for the assessing the impacts of climate change on marine resources and mitigation is a major concern now. Management strategy evaluation (MSE) of the climate change and its impact on marine ecosystem is a complex process based on the real time data analysis related to climate, natural recourses and socio- economic conditions along coastal region. In order to provide the people along coastal region with better prospects and opportunities for economic development, aquaculture development and management; increased participation of people along coastal region in electronic governance through information and communication technologies are envisaged. The Information and Communication Technologies (ICTs) plays an important role bridging the gap between social and natural science uncertainties in marine ecosystem.

This presentation aims to explore the nature, role and relevance of the Electronic/Digital Governance using ICTs for assessing the impacts of climate change and mitigation for marine resources along coastal region and its impacts to highlight approaches and methods for improving local environmental governance for actors involved in socio-political process. The presentation will examine the current status of management strategy evaluation of marine ecosystems along the coast in different coastal regions of Asia- Pacific for the assessment of impacts of climate change and environment resilience along coastal regions using ICTs. The presentation deals with innovative ideas for effective communication strategies to convey MSE predictions and best-practice paradigms in the Asia-Pacific coast to decision-makers for effective planning and management of ocean and marine ecosystems.

Oral presentation

FISHERMEN SOCIAL REBOUND TO MEET THE EQUILIBRIUM IN FISHERIES MANAGEMENT: STUDY CASE NEW REGULATION ON LOBSTER FISHERIES IN SOUTHERN JAVA, INDONESIA.

Dwijayanti A.D., Suadi S.S., Setyobudi E.S., Adharini R.I.A.

Lobster is high economic value commodity in the last 30 years in Indonesia and most in the South East Asia. Most of these commodities are exported alive to several countries such as China, Hongkong, Vietnam, and Singapore. Since 2015 there has been a regulation issued by the Ministry of Marine and Fisheries of Indonesia. The prohibition of catching and selling lobster and lobster juvenile and set the size limit for the catch. The implications of this regulation decrease the lobster exports to China by 74.19%, and Vietnam by 94.03% from 2013-2016, meanwhile there was an export increase to Hong Kong 67.59% and Singapore 453%. This prohibition is stringent and causes some changes in social interaction in fisherman community and requires the fishermen and sellers to adapt. The fishermen's adaptation strategy which is affected stakeholders is important to be noted to evaluate the effectiveness of established rules and providing the proper management communication to gain the fishermen awareness of the uncertainty lobster resource. The research was conducted in four provinces; West Java, Central Java, Yogyakarta and East Java by conducting surveys and interviews to 200 fishermen and stakeholders. During the transition's period, the fisherman has been split into several groups which are based on decision options which have the correlation with the economic return and consideration of the lobster sustainability. Regarding the implementation of the new regulations, there are significant changes both in value and supply chain in upstream and downstream. The new domestic demand for ineligible lobster for export is growing and treated the effectiveness of the regulation. However, this occurrence is predicted as a social rebound for the new regulation and by implementing a precautionary approach to gain the fisherman and local market awareness because the regulation has significant advantages to be maintained eventually.

Oral presentation

GETTING ON THE SAME PAGE, OR AT LEAST IN THE SAME LIBRARY: LESSONS IN COMMUNICATION FROM A STAKEHOLDER DRIVEN MSE FOR NORTHEAST US ATLANTIC HERRING

Deroba J.J., Gaichas S.K., Lee M-Y., Feeney R.G., Boelke D., Irwin B.

Management Strategy Evaluation (MSE) should include stakeholder input, but such a process can have communication challenges. Atlantic herring in the northeast US has diverse and engaged stakeholders. An MSE was recently conducted to evaluate harvest control rules for Atlantic herring, possibly the first in the US to use open, public workshops for development. Two, 2-day workshops were each attended by about 65 members of the public, with about 30 attending both. Participants had diverse backgrounds with differing levels of interest and preparedness. This diversity of participation was generally positive, but led to frequent misunderstandings about terminology and intentions for the MSE. The process overcame some of these communication problems by providing a forum for repeated interactions and presenting information using a range of methods (e.g., verbally and graphically). Improved understanding of MSE and technical methods was also achieved through informal lines of dialog that opened through the MSE process. MSEs more broadly would benefit from repeated opportunities for interactions among stakeholders, scientists, and managers. Conducting stakeholder driven MSEs will require investment in organizers, facilitators, and technical experts, preferably with expertise in a particular system, and such investments can improve communication, understanding of MSE, to the betterment of fisheries management.

Oral presentation

HOW DO WE MOVE TO ECOSYSTEM BASED MANAGEMENT?

Hall J.A.

Ecosystem base management (EBM) for the marine environment has been discussed for long time but there are few examples where it has been consistently applied and none at the national level. The development of approaches, tools and frameworks for implementing EBM requires the integration of social science, economics, biophysical science, law, policy and indigenous knowledge. In addition, it needs to acceptance of EBM as a useful and practical management approach for the marine environment by marine resource managers, policy makers, industry, NGO's, indigenous people and the wider community. In New Zealand we have the opportunity to build approaches, tools and frameworks to support the evolution of EBM from our current system of single species fisheries management and managing each activity in the marine environment in isolation through the Sustainable Seas National Science Challenge, <http://sustainableseaschallenge.co.nz/>. A set of principles for EBM in New Zealand have been developed which include

- A co-governance and co-design structure that recognises the Māori constitutional relationship and mana whenua at all levels together with the guiding concepts of mauri, whakapapa, kaitiakitanga, and manaakitanga,
- Place- and time-specific, recognizing/understanding the ecosystem as a whole in all its ecological complexities and connectedness
- Acknowledgement of humans as ecosystem components with multiple values
- Long-term sustainability as a fundamental value, in particular maintaining values and uses for future generations
- Collaborative and participatory management throughout whole process, considering all values and addressing cumulative and multiple stressors,
- Clear goals and objectives based on knowledge

- Adaptive management, appropriate monitoring, and acknowledgement of uncertainty

This presentation will discuss how we have developed an interdisciplinary research programme to undertake the research needed to move New Zealand to EBM for our marine environment, what we have learnt so far and what our biggest challenges are in the future.

Oral presentation

#### DEALING WITH 'THE BOSS' IN THE BARENTS SEA – AS EASY AS IT SOUNDS?

Hansen C., Kaplan I.C., Skern-Mauritzen M., Morzaria-Luna H.N.

The cod stock in the Barents Sea is the largest cod stock in the world, often dubbed 'the boss' with current landings having a total value of 6.2 billion NOK. One of its favorite prey is capelin, however, cod is a top predator and generalist, and prey on almost all trophic levels. Lately, questions are being raised from pelagic fishermen about prioritizing the catches of cod 'on behalf' of other commercial species in the region. When the cod stock is at such high levels as present, it consumes a considerable amount of prey species. One of these is the Norwegian Spring-Spawning herring, which spends their juvenile period in the Barents Sea. Compared to the cod stock, the herring landings have a total value of 2.4 billion NOK at present stock levels. The suggestion from the fishermen is to fish harder on a high cod stock, and that way get more pelagic fish, but is the solution as easy as that? Could indirect predator-prey effects kick in and give fishermen, scientists and managers a bit of a surprise?

We propose that the structural uncertainty in multispecies models is of importance to the performance of management strategies. How crucial is a correct cod diet in an ecosystem model, in terms of the consequences of increased or decreased harvest pressure? To enlighten this, we use the Nordic and Barents Seas Atlantis model to evaluate the effects of changes in management strategies for the cod stock in the Barents Sea and evaluate the trade-offs and effects on the ecosystem and fisheries in the area.

Oral presentation

#### FACTORS AFFECTING DISTRIBUTION OF THE ATLANTIC SURFCLAM (*SPISULA SOLIDISSIMA*), A CONTINENTAL SHELF BIOMASS DOMINANT, DURING A PERIOD OF CLIMATE CHANGE

Hofmann E.E., Powell E.N., Klinck J.M., Munroe D.M., Mann R., Haidvogel D.B., Narváez D.A., Zhang X., Kuykendall K.M.

The Atlantic surfclam (*Spisula solidissima*) is a dominant member of the biological community of the Middle Atlantic Bight continental shelf and also a commercially harvested species. Climate warming is affecting the biology and distribution of this species, which provides an opportunity to investigate the processes and conditions that are restructuring this fishery and the implications for ecological and socio-economic systems. The Management Strategy Evaluation (MSE), which is a system of linked models, developed for the surfclam fishery is an attempt to provide a comprehensive mechanistic description of the surfclam's response to climate change and understand the cascade of effects initiated by changes in oceanographic conditions that ultimately appear as social and economic effects, which in turn inform

development of management policies for the resource. This presentation provides an overview of the components of the surfclam MSE, relevant results, and implications for management and policy. The lessons learned from the surfclam MSE provide a basis for applying similar approaches to other ecologically important species that are also commercially exploitable resources.

Oral presentaiion

#### REDUS MSE: A FLEXIBLE MANAGEMENT STRATEGY EVALUATION MODELLING TOOL

Howell D.

In principle, MSEs give the potential to move beyond our traditional single-species dominated management approaches. MSEs allow for testing of different single- and multi-species HCRs, for evaluating impacts beyond the target species, and for evaluating and communicating which uncertainties have the greatest impact on our management success. These factors have the potential to combine to give a wider scope to strategic management than has traditionally been possible. However, existing MSE tools tend to have been hardcoded and inflexible, and written with a much narrower scope, focusing only on single species, typically concentrating on numeric uncertainties in recruitment and assessment. This is beginning to prove a limitation on both research and the provision of management advice. For example, IMR Norway was recently asked by governments to evaluate a HCR for NEA cod which partially depended of varying food (capelin) availability. None of the existing tools could adequately handle this request. Equally, there was a recent MSE in the US to evaluate a HCR for herring considering its role in the ecosystem. Rather than continue to develop ad hoc solutions as such instances arise, IMR is therefore working as part of the REDUS project to create a modular MSE tool, where a central core in R connects via APIs to existing state-of-the-art single- and multi-species operating models. This will allow a much wider range of structural uncertainties to be evaluated, as well as including a wider multispecies perspective in the analyses. This presentation will briefly present the design and aims of the MSE tool. We present this hoping to feed into, and learn from, the discussion on the future development of MSEs.

Oral presentation

#### OPTIMIZING FISHING STRATEGIES AND SPATIAL MANAGEMENT BY LINKING SPATIAL ABUNDANCE INFORMATION AND ECONOMIC INDICATORS

Ishimura G.I.

Spatial analysis is used extensively in natural resource management to optimize resource uses as well as fishing operations. This study undertakes the daily log-book and market data for a Japanese off-shore longline fishing vessel for the North Pacific swordfish fishery. To explore optimum fishing strategies, this study intergrades two analysis (a) spatial analysis of resource abundance with identified fishing grounds by cluster analyses and (b) the development of an empirically-estimated production function with the ex-vessel price model upon quality and quantity of landings and the cost model. The results suggest that; 1) the



possibilities for the seasonal fishing strategies to improve and optimize their profitability and 2) potential boundaries for the spatial fishery resource management with consideration of fishers' behavior.

Oral presentation

#### TESTING HARVEST CONTROL RULES WITHIN END-TO-END ECOSYSTEM MODELS: A STEPPING STONE TOWARD MANAGEMENT STRATEGY EVALUATION

Kaplan I.C., Hansen C., Morzaria Luna H., Girardin R., Marshall K.N.

Management strategy evaluation (MSE) provides a simulation framework to test the performance of living marine resource management. MSE has now been adopted broadly for use in single-species fishery management, often using a relatively simple 'operating model' that projects population dynamics of one species forward in time. On the other hand, many challenges in ecosystem-based management involve tradeoffs between multiple species and interactions of multiple stressors. Efforts are underway to include these dynamics in more complex 'end-to-end' ecosystem models that can serve as operating models for MSE, but to date the most fruitful ecosystem-based MSE approach has often been to strip the ecosystem model (operating model) down to intermediate levels of complexity (often 3-5 species). Here we take a different tack, retaining the complexity of end-to-end ecosystem models (for the California Current and Nordic/Barents Sea), stripping down the simulated assessment in the MSE, and testing harvest control rules that explicitly address the linkage between predators and prey, and between forage needs of predators and fisheries.

We test harvest control rules that

- 1) Explicitly include potential for prey-driven shifts in predator productivity. We vary the intensity of fishing on a predator (Pacific hake) dependent on the availability of prey (euphausiids) that may drive productivity shifts in the predator.
- 2) Provide a threshold of forage biomass, below which fishing on forage is eliminated and forage is reserved for predators. We test threshold levels of prey (copepod *Calanus finmarchicus*) abundance below which copepod fisheries are closed.

These ecosystem-based harvest control rules that address shifting productivity or threshold forage biomass are not novel, but here we explore their implications for different trophic levels and the structure, function, and catches at the ecosystem level. We adopt lessons learned from other (mostly single-species) MSE efforts in terms of how to score, plot, and summarize model performance.

Oral presentation

#### MODELING THE IMPLICATIONS OF STOCK MIXING AND LIFE HISTORY UNCERTAINTY OF ATLANTIC BLUEFIN TUNA

Kerr L.A., Cadrin S.X., Morse M., Secor D.H., Taylor N.G.

Atlantic bluefin tuna (*Thunnus thynnus*) is currently managed as separate eastern and western stocks. However, tagging and otolith chemistry patterns suggest that the two stocks mix seasonally and return to natal areas to spawn. Using a simulation model, we explored how scenarios of population-specific migration and uncertainty in aspects of bluefin tuna biology affect the long-term magnitude, distribution, and mixed stock nature of the resource and catch of its associated fisheries under current fishing conditions. The analytical framework was a stochastic, age-structured, stock-overlap model that was seasonally and spatially explicit with movement of eastern- and western-origin tuna informed by tagging data. Alternate estimates of movement and assumptions regarding maturity and recruitment regime for western origin fish were considered. Simulation of the operating model indicated considerable stock mixing in the western and central Atlantic, which resulted in differences between the stock and population view of western bluefin tuna. The relative biomass of the western population and its spatial and temporal distribution in the Atlantic was sensitive to model assumptions and configurations. Based on this model we developed biological reference points for bluefin tuna that incorporate the influence of mixing, as well as different productivity regimes, and maturity assumptions. Management strategy evaluation based on the spatially complex operating model and simpler estimation models are being used to test alternative management strategies against the goal of maximum sustainable yield of eastern and western spawning populations.

Oral presentation

#### FACTORS OF SOCIAL VULNERABILITY TO CLIMATE CHANGE AMONG SMALL-SCALE FISHING COMMUNITIES FROM THE SOUTH BRAZIL BIGHT

Martins I.M., Gasalla M.A.

Small-scale fishers are often susceptible to climate change due to a series of factors and policy trends that limit their adaptive capacity. Understanding the vulnerabilities of fishing communities and their strategies to cope with and adapt to climatic change is crucial for promoting actions that secure their livelihoods in multiple contexts. Vulnerability has been seen as a function of sensitivity, exposure, and adaptive capacity which involves the ability to anticipate, respond, and recover from the consequences of change. In such a context, the present study aimed to understand the patterns of vulnerability and adaptive capacity among eight different coastal communities of the South Brazil Bight. An integrated framework developed by the GULLS consortium (a Belmont Forum multilateral project) was adopted to allow for international and inter-regional comparisons. A total of 151 households were locally approached, interviewed and sampled in the selected communities that represent a comprehensive illustration of fishing villages from this region. Results shows that communities remoteness and lack of institutional support related to climate change are important drivers of vulnerability, while community organization, strong leadership, partnership with researchers, and resources co-management are factors that reduce vulnerability and increase adaptive capacity. Our findings represent the first social vulnerability assessment of fishing communities to climate change in the region, and generate new understanding of the issue by providing perspectives that should enhance resilience and adaptation.

Oral presentation

## CLIMATE ADAPTATION IN NORTHEAST U. S. FISHERIES: ELICITING AND EVALUATING STRATEGIES OF INTEREST TO STAKEHOLDERS AND COMMUNITIES

Mills K.E., Hudson M., Colburn L.L., Eayrs S., Hartley T.W., Labaree J., Allyn A., Franklin B., Hare J.A., Kennedy B., Pershing A.J., Sun J., Thunberg E.

Across the globe, climate change is affecting marine ecosystems, fish populations, and fisheries. At local scales, climate impacts emerge in distinct ways depending on the nature and rate of ecosystem change, ways in which societies use marine resources, and adaptive capacity. In the Northeast United States, marine waters have warmed rapidly over the past decade, and impacts have been felt in culturally and economically important fisheries. Fisheries are responding to changes in resource populations and the marine ecosystem in a variety of ways: fishermen travel further to target their traditional species, switch to new species that have become prevalent in their typical fishing areas, and diversify into opportunities outside of capture fisheries. However, adaptation has largely been limited to individual-level and industry-motivated actions to date, and there is widespread recognition that management system flexibility is necessary to facilitate further adaptation. Interviews with fishery stakeholders and municipal officials in four Northeast U. S. ports (i.e., Stonington, ME; Portland, ME; New Bedford, MA; Point Judith, RI) that span a range of geographies and fisheries reveal ways in which fishermen and their communities have already responded to climate-related ecosystem changes, ways in which they want to be able to adapt in the future, and factors that facilitate and constrain adaptation (e.g., capital, knowledge, institutional arrangements). The adaptation strategies derived from these interviews are being evaluated as scenarios within a social-ecological vulnerability assessment framework that uses ecological and economic models to evaluate costs, benefits, and outcomes for fishing communities. As these strategies reflect stakeholder interests and community objectives, they can also be valuable for shaping objectives and selecting management strategies within MSE initiatives, particularly for informing social dimensions of initiatives that seek to represent the influence of climate change.

Oral presentation

## A NEW CONCEPTUAL FRAMEWORK TO EVALUATE DRIVERS OF FISHING BEHAVIOR IN SMALL SCALE FISHERIES

Miñarro S., Galbraith E.

Current overpopulation and technological advances inevitably increase human pressure on marine resources, leaving responsible management as the only viable solution to achieve fisheries sustainability. In particular, the influence of small-scale fisheries' in the global wild catch appears to be much stronger than previously thought, and their catch is declining, while their complexity and context-dependency are displayed by contradicting studies of successful and failed small-scale fisheries management examples around the world. We present a conceptual framework to quantify the effect of fishers' goals and motivations on their fishing behavior and proneness to change. The framework aims to be applicable to small scale fisheries regardless of geographic location, and is based on the three-dimensional well-being concept. Fishing community characteristics such as their perceived fairness of the fishery organization, community cohesion, access to fisheries-derived benefits or environmental identity are assessed against the

fishers' preferences of time allocation to fishing under different scenarios of resource abundance, invested capital, catch and seafood market price. This framework aims to contribute to disentangle the complexity of social dynamics and priorities influencing human exploitation behavior and trade-offs toward coastal marine resources.

Poster presentation

#### A MODEL-BASED APPROACH FOR STRENGTHENING RESILIENCE OF RESPONSIBLE MARINE FISHING AREAS IN COSTA RICA

Naranjo-Madrigal H., Elizondo-Mora S.

The complexity of socio-ecological fisheries systems, defined by their importance as a source of income, employment, food security and cultural traditions, requires the use of emerging systemic thinking concepts to face the challenges involved in their management. Although, the management of marine fisheries in developing countries is still restricted to optimization paradigms as well as top-down management initiatives, data inefficient, and poorly adapted to case-specific ecological and socioeconomic conditions. The Responsible Marine Fishing Area (RMFA), created in 2008, is a management tool developed by the Costa Rican government in order to recognize the role of fishers' organizations in small-scale fisheries management. It was investigated case studies primarily from the Pacific Gulf of Nicoya region with the aim to identify linkages between the property right (PR) management approach, the Operational Procedure of the Code of Conduct for Responsible Fishing (OPCCRF) and the RMFAs in practice. Three sources of information -Users, Experts and Government entities- are analyzed to define the functioning of RMFAs, its relation to the OPCCRF and the quality of the PR. Bayesian Networks are used to evaluate relationships between the function of RMFAs, the OPCCRF, the quality of the PR, and the degree of co-management achieved. An alternative model of a desirable scenario of governance is proposed to guide management interventions and strengthening resilience of RMFAs, such as capacity building and research projects.

Poster presentation

#### FISHING FOR POWER: CONCEPTUALIZATION OF SOCIAL-ECOLOGICAL CHANGE AND MARGINALIZATION THROUGH LOCAL METAPHORS AND POLITICAL ECOLOGY NARRATIVES

Nayak P.K.

The main focus of this paper is on the role of qualitative data in further developing and implementing Management Strategy Evaluation (MSE) as a tool for sustainable fisheries. The paper investigates social-ecological change and marginalisation in small-scale fishing communities of Bay of Bengal, India. It considers changes in recent decades, impacting the social, cultural, economic, political and environmental life of fishers that have resulted in their disconnection from the fishery and marginalisation. However, there exist a paradox with regard to environmental change and fishers' marginalisation in Bay of Bengal: an official account of ecological stability along with local economic growth vs. fishers' experience of fishery depletion and decrease in their income levels. The paradox of the official account of "development" and the fishers' views about their own marginalization indicates a conundrum which I examine further in this paper.

Fishers' views through metaphors they use to express environmental change processes and their marginalization are combined with political ecology narratives as a qualitative framework and an analytical tool for achieving management success and sustainable fisheries.

Linking political and ecological strands of environmental change discourses in the Bay of Bengal helps to analyze issues across a range of levels, from very micro to macro, by focusing on the influence that society, state, corporate, and transnational powers have on creating or intensifying environmental problems and influencing environmental change. The paper seeks to address gaps in dominant approaches to the study of environmental history and politics by bringing into focus the perspectives (e.g., metaphors) of local fishers, marginal groups, and vulnerable populations and using them in tandem with more sophisticated approaches such as Political Ecology. The promise lies in the potential contribution this novel approach can bring to Management Strategy Evaluation (MSE) as a tool to assess fisheries sustainability.

Oral presentation

#### EXPLORING TRADITIONAL ECOLOGICAL KNOWLEDGE (TEK) MARINE RESOURCES USE: A CASE STUDY FROM TWO VILLAGES IN FIJI

Qaqara N., Lowry J., Piovano S., Ryle J., Veitayaki J.

Traditional Ecological Knowledge (TEK) is the body of knowledge, beliefs, values and traditions held by a specific people about their local ecosystems. Pacific Islands are considered a region with rich knowledge of TEK which has been practiced by the people for many years and passed down from generation to generation. TEK has been rapidly changing in past years due to the influence of foreign ideas and scientific knowledge on marine resource management. In depth research is required to understand the importance of TEK and incorporate this knowledge into marine resource management plans in the Pacific.

The gaps between TEK and scientific knowledge have been acknowledged. Thus researchers need to put emphasis in documenting TEK so that factors that influence the ineffectiveness of the integration between TEK and scientific knowledge could be recognized.

This research will identify the TEK of two communities in relation to how different gender and age group use perceive and locate their fishing ground and marine resources. This pilot study will be carried out in two communities in Fiji. Several research methods will be employed such as Participatory GIS (PGIS), biological survey and ethnographic research. These research methods will complement each other and primarily aim to build effective collaboration between local resource owners and researchers in data collection.

In developing a GIS database it will be useful for the people in Fiji as well as the Pacific Islands to recognize the impact of natural and anthropogenic influences on marine environment and areas where better solutions for marine management can be identified. Recommendations and lessons learn from this research will be used to strengthen fisheries management in Fiji and the Pacific Islands communities.

Oral presentation

#### MAPPING THE HUMAN DIMENSIONS OF ANALYTIC TOOLS FOR FISHERIES MANAGEMENT

Sbrocchi C.D., Barclay K., Fulton E.A.

Fisheries are often more than a business – they are a connection to the sea, a livelihood and part of a wider social fabric. However, existing fishing rules typically do not account for the myriad interactions happening below and above the sea - the complexity of ecological interactions, external drivers, local socio-economic issues and institutional constraints.

My PhD project involves evaluating existing fisheries decision support tools for their ability to account for environmental, social, economic, institutional and sustainability objectives. This comparative analysis will provide some understanding of the strengths and weaknesses of different tools as socio-ecological assessment frameworks for reporting on multiple objectives, particularly the socio-political dimensions of fisheries. This process will highlight how and where information from the social sciences can influence or direct MSE development.

Finding ways to better integrate the ‘human’ with the ‘environmental’ will help managers and policy makers to make more transparent, equitable and fair decisions. It will also help fishers and other community members become an integral part of the decision making process, by making their long-term needs a factor in the decision.

Oral presentation

DEVELOPING HARVEST STRATEGIES FOR THE WESTERN CENTRAL PACIFIC TUNA FISHERY

Scott R., Reid C.

The annual tuna catch from fisheries of the Western Central Pacific Ocean (WCPO) in recent years has been in excess of 2.5 million tonnes, accounting for more than 50% of the global tuna catch and having a total estimated catch value in 2015 of around \$5 billion. As the fisheries have developed, management discussions at the sub-regional (e.g. the Parties to the Nauru Agreement and the Forum Fisheries Agency members) and regional (Western and Central Pacific Fisheries Commission) level have moved toward a formalised harvest strategy approach. The development of harvest strategies has been challenging due to the differing management objectives within the region's fisheries, in particular those of the different stakeholders within the purse seine fishery and target skipjack stock, and the south Pacific longline fishery and its albacore target stock. We provide an overview of the state of the tuna fishery in the WCPO, the challenges encountered in developing and agreeing the components of WCPO harvest strategies, and anticipated developments in the near future.

Oral presentation

EVIDENCE OF ECOSYSTEM BASED ADAPTATION IN COASTAL FISHERIES OF BANGLADESH

Selim S.A., Bhowmik J.

Coastal waters of Bangladesh support extraordinary high levels of biological productivity including productive fisheries vital to the economy and food security of Bangladesh. At the same time, Bangladesh coast globally among the most vulnerable to climate change, where the coastal population are highly dependent on coastal ecosystem natural resources. The importance of fish habitats and biodiversity is enormous for the livelihoods of millions of people, trade, jobs and protein supply here. There is mounting evidence that demonstrate the impacts of climate change on fisheries.

Ecosystem Based Adaptation (EBA), a type of Ecosystem-based management, uses biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at different scales. Ecosystem based Adaptation (EbA) has great potential to increase people's resilience and ability to adapt, but it is not yet integrated in national and international policy processes and its use in fisheries sector is limited. In this study, we review a selection of community based adaptation practices that were developed as part of the CREL (Climate Resilient Ecosystem and Livelihoods) project along the coastal region of Bangladesh. We use an EbA framework to understand benefits and co-benefits, opportunities and challenges in management and adaptation of coastal ecosystems and fisheries to impacts of climate change.

Oral presentation

EMERGING GOVERNANCE REQUIREMENTS: MANAGE FISH AND PEOPLE FOR A COHERENT AND SUSTAINABLE EXPLOITATION IN THE ROMANIAN BLACK SEA

Vaidianu N.

In Romania, there is a more intense pressure on the marine resources, especially on fisheries. Marine fisheries have been overexploited in the last 70 years, in the form of open-access common until 1989 and under regulations after 1990, especially after EU accession in 2007. Consequently, the fish stocks are on the huge decline which induce evidence that these declines are being countered by changes in either fishing regulations or fishing practices. Because of these shifts, fishermen frequently comply with new regulations and operationalisations. In these circumstances understanding how fishermen perceive the new Natura 2000 expansion and use resources is very important for management and policy implications. Our study examined fishermen's perceptions about the state of fish stocks and emerging governance and management strategies in Romania. We surveyed fishermen in Sfântu Gheorghe village, Danube Delta Biosphere Reserve. We found that all fishermen perceived a decline in catch and this extend (until 40 m depth) will affect their activity. Conflicts raise because they must adapt to these declines by increasing fishing area and time spent, changing their gear, and overlapping in fishing zones. Even there is a Strategy for sustainable development in the Danube Delta, we identified an incoherence of regulations with government incentives. Questions regarding sustainable governance in its encompassing understanding come more to the fore, by far not only relating to environmental concerns. Until now, those interactions have not been tackled very actively neither in governance nor conservation planning. However, the need is well recognised. Valuable

applied approaches, like integrated coastal zone management and marine spatial planning, have attempted to take a more holistic approach. We recommend strengthening local fishing communities by enabling them to enforce fishing regulations locally. However, this is often not yet reflected in the existing governance regimes.

Oral presentation

#### DEVELOPING A FRAMEWORK FOR EVALUATING STRUCTURAL UNCERTAINTY IN SOCIAL-ECOLOGICAL SYSTEM MODELS: A BAYESIAN NETWORK APPROACH

Wildermuth R.P.

Management strategy evaluation entails modeling the dynamic response of a social-ecological system to prescribed management actions and determining whether system indicators are likely to meet thresholds for one or more objectives. Developing models of marine social-ecological systems means analysts must confront multiple uncertainties that are difficult to test empirically due to the complexity of marine systems and gaps in data availability. Notably, choices about model structure and functional forms have important influences on model estimates and management outcomes. Sensitivity analyses assessing these choices are difficult and costly to perform, particularly for whole-of-system models. I develop a framework to assess uncertainty in social-ecological model structure using a Bayesian network approach for the Georges Bank marine system. Bayesian networks define semi-quantitative probability relationships between potential states of system components in a network. I describe how empirical data on Georges Bank indicators and expert knowledge are combined to construct a dynamic Bayesian network to assess performance of ecosystem-based management strategies. The Georges Bank system model is composed of physical, ecological, and socioeconomic components signifying indicator data. Two levels of complexity representing simpler and more complex bioeconomic model structures are explored to contrast assumptions and hypotheses about the human dimensions of the system found in classical assessments. Evaluating “what if” queries from these Bayesian network structures helps assess robustness of management strategies to structural uncertainty and provides an ensemble of potential outcomes related to multiple management objectives. This framework helps address 1) sensitivity to choices about model structure when incorporating economic and social factors and objectives in whole-of-system models and 2) difficulties integrating qualitative information into social-ecological models to fill quantitative data gaps. Finally, the approach presented here proposes the development of whole-of-system models using Bayesian network methods and explores the strengths and weaknesses of these methods for use in management strategy evaluation.

Oral presentation

#### EFFECTS OF CLIMATE CHANGE AND FISHING ON THE PEARL RIVER ESTUARY ECOSYSTEM AND FISHERIES

Zeng Z., Cheung W.W.L., Li S., Hu J., Wang Y.

Climate change is considered as a new threat to fish stock and marine ecosystems and a new challenge to management of ocean biodiversity. In Pearl River Estuary (PRE), climate change would make this area confront unprecedented and hard to predict stresses, which has experienced overexploiting fish resource



since 1980's. Understanding the ecosystem response to climate change and interactions with fishing activity is paramount to predicting future ecosystem states in the PRE. We linked the simulation results of climate change scenarios (RCP 2.6 and RCP 8.5) from Geophysical Fluid Dynamics Laboratory Earth System Model ESM2M with Ecosim for the PRE to predict changes in landings, biomass and indicators of community composition under individual climate factors and combined climate impacts with different level of fishing efforts in 2050. Under individual factors effects, primary production change and temperature change are important implications for landings and biomass. Biomass changes indicate that the response of species to climate change depended on interactions between the physiological and ecological processes. Physiological processes are likely modified when indirect effects are taken into consideration alongside direct effects in ecological level, specially for top-down control ecosystem state. Climate change is predicted to be potential threat to fisheries and ecosystem in PRE, especially for the overexploited high-value demersal fish species. Reducing fishing efforts can mitigate the effects of climate change on some functional groups, but some traditional commercial demersal fish are potential to experience higher predation mortality which causes their biomass decreasing in low fishing scenarios. Our consequences highlight the sensitivity of demersal fish to both fishing and climate change impacts in PRE. Our projection provides future analytical and empirical studies with hypotheses of climate change impacts, which can be a climate change-adaptation foundation for the future fish resource management in PRE.

Oral presentation