

The background of the poster is a composite image. The top portion shows a city skyline with various skyscrapers under a clear sky. Below the horizon line, a fishing boat is visible on the surface. Underneath the water, a large, circular fishing net is shown, filled with a dense school of small, silvery fish. The net is made of a fine mesh and is illuminated from above, creating a shimmering effect. The overall color palette is dominated by blues and greens, with the white text providing a strong contrast.

IMBIZO IV

MARINE AND HUMAN SYSTEMS

Addressing multiple scales and multiple stressors

26-30 Oct 2015 — **TRIESTE (Italy)**

Marine ecosystem-based governance: from rhetoric to reality
Upwelling ecosystems - models for interdisciplinary global change studies
Modelling for marine social-ecological systems
Regime shifts to novel systems

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26-30 October 2015

Trieste, Italy

Produced by: **IMBER International Project Office**
IMBER Regional Project Office

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Welcome

It is great that so many people are eager to unravel the secrets of the oceans, to understand how the oceans are impacted by societies and how the oceans affect societies. The conveners and organizers welcome you to the fourth Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) IMBIZO (the Zulu word for a gathering). The topic of this IMBIZO, *Marine and human systems: Addressing multiple scales and multiple stressors*, continues the IMBER focus on fostering research that goes across natural and social sciences. We are here to discuss and synthesize the current state of knowledge in marine and human systems and their governance, and to identify key questions to be addressed by the IMBER research community. The four workshops developed for this IMBIZO address scientifically compelling marine systems and their linkages to social and governance systems. This IMBIZO brings together over 100 researchers from all career stages from 26 countries. We are pleased that one third of the participants are early career scientists.

It is appropriate that IMBIZO IV is hosted by the Istituto Nazionale di Oceanografia and Geofisica Sperimentale (OGS) and is held at The Abdus Salam International Centre for Theoretical Physics (ITCP) in Trieste. OGS has a long and distinguished research history that has provided important contributions to Earth system science, many of which have been successfully transferred to address interlinked environmental, economical, and social issues. The ITCP has advanced research excellence in physical and mathematical sciences for over 50 years and has served to provide a forum for promoting international scientific exchanges.

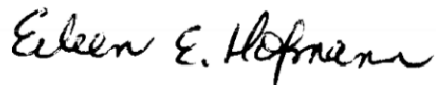
This IMBIZO is dedicated to the memory of Kon-Kee (KK) Liu. KK was an active member of the IMBER community, serving as co-chair of the Continental Margins Working Group and as co-convenor of the 2013 IMBIZO III. One of KK's final efforts was a synthesis that laid out the importance of continental margins for global resilience and sustainability. The research questions identified stressed the need for linked social-ecological system research, sustainable development and sharing of natural resources, and governance systems for sustainability. Although focused on continental margins, the ideas and recommendations arising from this synthesis are relevant to the four IMBIZO workshops. Thus, KK's presence will be felt at this IMBIZO. His guidance and advice will continue through his many scientific contributions in ocean biogeochemistry, and through the generation of scientists that he taught and mentored. Many are now part of the IMBER community and provide a continuing legacy of KK's influence.

Events like the IMBIZO are possible only because of the hard work and dedication of the local organizing committee, the programme committee, the workshop conveners, the staff of the IMBER International Project Office (Institute of Marine Research, Bergen) and the IMBER Regional Project Office (East China Normal University, Shanghai), and financial support from sponsors. Without the efforts of many and generous financial support, it would not have been possible to convene the IMBIZO.

Welcome

The success of IMBIZO IV depends not only on the well prepared plenary and workshop presentations. The interactions and discussions that arise during the workshops and poster sessions, and sometimes even more importantly, over lunch, dinner or in the coffee breaks, provide great opportunities for identifying critical questions, swapping ideas and forging collaborations. We hope these and the plenary interaction debates and discussions will make IMBIZO IV an event to remember. The outputs and results from these will be captured in the publications and special issues that are planned for IMBIZO IV.

We wish you a productive, enjoyable and stimulating IMBIZO and hope you return home with good memories, new ideas, and new colleagues.



Eileen Hofmann, Chair IMBER SSC
on behalf of the
IMBIZO organizers and conveners

Welcome

Dear IMBIZO Participants,

Welcome to Triest, Benvenuti a Trieste, Dobrodošli v Trst! City of Science and Higher Education!

Trieste, OGS, ICTP and SISSA welcome you in a Sea of Science!

OGS is proud to host the IMBER IMBIZO IV in Italy and specifically in Trieste, a crossroad of cultures, science, communication and trading.

The core of IMBER IMBIZO is “interaction” and here you are hosted by three research institutes: OGS (Istituto di Oceanografia e Geofisica Sperimentale), ICTP (International Center of Theoretical Physics) and SISSA (International School for Advanced Studies). These are national and international research centers with the mission of advancing science and technology and of training and educating foreign scientists from developing countries.

We hope you will “dive” within this intense interaction network across the marine and the human systems and you will take part in addressing the multiple stressors that are challenging our society.

We wish a successful meeting in Trieste.



Maria Cristina Pedicchio
President of OGS

Organisers

Scientific Organising Committee:

Ingrid van Putten (Co-Chair): CSIRO and University of Tasmania, Australia

Javier Arístegui (Co-Chair): Universidad de Las Palmas de Gran Canaria, Spain

Alida Bundy: Bedford Institute of Oceanography, Canada

Julie Hall: National Institute of Water and Atmospheric Research, New Zealand

Eileen Hofmann: Old Dominion University, USA

Einar Svendsen: IMBER International Project Office, Norway

Local Organising Committee:

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Italy

Michele Giani (Chair)

Francesca Malfatti

Martina Kralj

Cinzia DeVittor

Francesca Petrerà

IMBER International Project Office (IPO):

Institute for Marine Research, Bergen, Norway

Lisa Maddison

Veslemøy Kjersti Villanger

IMBER Regional Project Office (RPO):

East China Normal University, Shanghai, China

Yi Xu

Fang Zuo

Summary and format

Overall Theme of IMBIZO IV:

Marine and human systems: *Addressing multiple scales and multiple stressors*

Summary

Marine ecosystems are amongst the most productive ecosystems in the world, providing benefits that humans depend on for survival, food, livelihoods and well-being. The interactions between humans and marine systems are complex, and are continually evolving as they mitigate and adapt to the cumulative effects of global change.

The multiple stressors and drivers of global change in the marine and human systems differ geographically, depending on whether they occur in coastal areas, the continental shelf, or the open ocean, and moreover, vary at temporal scales.

The challenge for ensuring sustainable governance of marine ecosystems and human societies in the future is the development of systems level understanding of the effects of global change at multiple scales. IMBIZO IV will explore the interactions of multiple drivers and stressors at different spatial and temporal scales. Of interest will be the global implications (and scaling up) of the responses of marine biogeochemistry, ecosystems, and social and governance structures observed at these different spatial and temporal scales.

Meeting Format

IMBIZO IV is structured around four concurrent and interacting workshops, with joint plenary and poster sessions. The four workshops are:

1. Marine ecosystem-based governance: From rhetoric to reality
2. Coastal upwelling ecosystems as models for interdisciplinary studies of climate and global change
3. Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change
4. From regime shifts to novel systems – evaluating the social-ecological implications of lasting ecosystem changes for resource management.

IMBIZO IV begins with keynote addresses that will provide an overview of the state of research and future directions for each of the four workshops and the basis for joint discussions

General Structure

All plenary sessions will be held in the Budinich Hall

The workshops are located as follows:

Workshop 1 (Governance): Room A

Workshop 3 (Modelling): Room B

Workshop 2 (Upwelling): Euler Hall

Workshop 4 (Regime shifts): Room D

IMBIZO IV - General Structure

	26-Oct Mon	27-Oct Tues	28-Oct Wed	29-Oct Thurs	30-Oct Fri
8:30		Welcome in Budinich Hall		Plenary report back session	Plenary report back session
9:00	Scientific writing workshop (Euler Hall)	Silvia Salas (Governance WS Keynote)	Four concurrent workshops	Four concurrent workshops	Four concurrent workshops
9:30		William Chueng (Upwelling WS Keynote)			
10:00			<i>Morning tea</i>	<i>Morning tea</i>	<i>Morning tea</i>
10:05		<i>Morning tea</i>			
10:30		Icarus Allen (Modelling WS Keynote 1)	Four concurrent workshops	Four concurrent workshops	Plenary report back and wrap up
10:40		<i>Morning tea</i>			
11:00		Barbara Paterson (Modelling WS Keynote 2)			
11:35		Scott Ling (Regime Shifts WS Keynote)	<i>Lunch</i>	<i>Lunch</i>	
12:00		<i>Lunch</i>			
12:10			Four concurrent workshops	Four concurrent workshops	
12:30	<i>Lunch</i>				
12:45	Proposal writing workshop (Euler Hall)	Four concurrent workshops	Four concurrent workshops		
13:00					
14:00		<i>Afternoon tea</i>	Plenary interaction Debate	Plenary interaction Discussion	
14:30		Four concurrent workshops			
15:30		<i>Afternoon tea</i>	Poster session (drinks and snacks)	IMBIZO Dinner	
15:45		Four concurrent workshops			
16:00					
16:15	Poster session & ice-breaker				
17:00					
17:30					
19:30					
20:00					

Workshop 1: Marine ecosystem-based governance: From rhetoric to reality



Dr. Silvia Salas is a fisheries scientist and professor at the Marine Resources Department at CINVESTAV in Merida, Mexico. She is the academic coordinator of the graduate program of the Marine Resources Department. Silvia is a member of the Mexican Academy of Science and engages in connecting research to management by participating in advisory committees of government agencies in Mexico and scientific meetings organized by FAO, WTO and WWF with that focus. Her research involves

bioeconomic assessment of small-scale fisheries, dynamics of the fleet, fishing strategies, and fishers' behaviour and risk perception. She has coordinated many research projects and published several scientific papers, book chapters and books on these themes. Currently she is collaborating with the international project "Too Big To Ignore - A global partnership for small-scale fisheries".

Abstract

LET'S COOPERATE: THE FIRST STEP IN MARINE ECOSYSTEM-BASED GOVERNANCE

Discussions of vulnerability, resilience and adaptive capacity in coastal communities are increasingly common in academic and non-academic fora. These concerns reflect the worldwide recognition of the challenges that coastal communities face in changing environments, changing markets, and under different types of stressors. In this context, it is important to identify the causal factors of vulnerability and to understand how people deal with them, in order to find ways to reduce the impact of future threats and to develop adaptive capacities for the impacted communities. I present three case studies from the Yucatan coast of Mexico to illustrate how changes in resource abundance, social networks, and policy interventions can affect community's vulnerability and adaptive capacity. Case 1): I demonstrate how divers targeting lobster and sea cucumber are forced to use tactics that affect their health and safety because of the reduced income resulting from the diminished resources. Case 2): I compare two fishing communities dealing with impacts of global environmental change (e.g. red tides, more frequent and intensified hurricanes) and reduced catches of their main target species, and indicate how fishers' skills and cooperative membership are key factors that differentiate their vulnerability and ability to respond to hazards. Case 3): I show how a new commercial sea cucumber fishery has created a 'gold rush' situation, transforming cohesive coastal communities into chaotic and dysfunctional groups, and bringing conflict to previously peaceful places. These case studies reveal the reality of marine resource governance in Yucatan and elsewhere, it is extremely complex and challenging. Hence, we need to go back to basics, and identify the factors underlying people's behaviour and the decisions that they make, especially under conditions of risk and uncertainty, and include this knowledge, and expertise beyond that which is normally incorporated in ecosystem-based approaches. I will also stress that, in order to reduce vulnerability and enhance adaptive capacity of coastal communities, it is necessary to promote cooperation amongst community members, scientists, and public institutions as the first step towards integrated ecosystem governance.

Keynote speakers

Workshop 2: Coastal upwelling ecosystems as models for interdisciplinary studies of climate and global change



Dr. William Cheung is an Associate Professor at the University of British Columbia, Vancouver, Canada. He is a Co-Director of the Nippon Foundation-UBC-Nereus Program. His main research area is assessing the biophysical and socio-economic vulnerabilities and impacts of climate change and other human stressors on global and regional marine ecosystems and fisheries, and identifying mitigation and adaptation options. His research examines global patterns and general theories related to the

responses and management of biophysical and socio-economic systems under global change, and apply the findings to research at regional and local scales. He works on various interdisciplinary research projects with global collaboration networks including U.K., Australia, Kenya, China and USA. He participates as Lead Author in various high level international assessments, such as the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Global Biodiversity Outlook (GBO) and Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

Abstract

IMPACTS OF GLOBAL CHANGE ON COASTAL UPWELLING ECOSYSTEMS AND FISHERIES

Coastal upwelling regions are amongst the most productive marine ecosystems, contributing largely to global fisheries production and human wellbeing. Changes in key ecosystem drivers, including temperature, oxygen level, acidity and primary production, directly affect coastal upwelling ecosystems and fisheries through shifts in biogeography, phenology, productivity and trophic interactions. Long-term management of these fisheries requires the consideration of global change. This talk aims to summarize the current status of fisheries in the major eastern boundary upwelling (EBU) regions, highlight the expected future changes in ocean conditions in these regions in the 21st century, and assess their implications for the sustainability of coastal upwelling ecosystems and fisheries. Specifically, I will present estimates of total fisheries production and their economic benefits in the four EBU regions from the latest catch reconstruction effort. I will also assess how some of the observed changes in catches may be attributed to climate change. I will then summarize projected changes in the key oceanographic drivers to EBU ecosystems and their uncertainties, including temperature, pH, oxygen level and net primary production. I will show projections of how exploited marine fishes and invertebrates in the EBU regions may respond to changes in these ecosystem drivers and the resulting impacts on catches and economic benefits of their fisheries. Finally, I will discuss the scope of fisheries management in adapting to the projected impacts from global change, the need for immediate actions and identify key knowledge gaps in ensuring sustainability of EBU fisheries.

Workshop 3: Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change



Dr. Barbara Paterson is a postdoc at Saint Mary's University in Halifax, Canada and an Honorary Research Associate of the Marine Research Institute of the University of Cape Town, South Africa. Her research interests focus on the integration of qualitative and quantitative methods for decision making for sustainable development in fields traditionally characterized by natural science approaches. Her expertise includes the development of electronic decision support tools for the management of natural resources.

Another focus of her research are the ethical and epistemological issues that arise when mathematical and computational approaches are applied in environmental and cross-cultural contexts. For the last ten years her work has focused on developing decision support methodologies to support the implementation of an ecosystem approach for fisheries (EAF) in Namibia and South Africa with particular focus on social-ecological knowledge. Her current research investigates social-ecological aspects of marine and coastal hazards.

Abstract

INTEGRATED MODELLING TO SUPPORT ASSESSMENT AND MANAGEMENT OF MARINE SOCIAL-ECOLOGICAL SYSTEMS IN THE FACE OF GLOBAL CHANGE – A SOCIAL SCIENCE PERSPECTIVE

The relationships between humans and the oceans have a long complex tradition and as a result there is today no marine ecosystem that is unaffected by anthropogenic change. What is equally concerning is that, as ocean ecosystems change, these changes impact on the lives of people in often devastating ways. Policy and decision makers need to consider these iterative interdependencies between the social and ecological dimensions, which require integrated assessments of marine social-ecological systems. Models and scenarios are well established in marine science, but, with the exception of economics, predictions and scenarios are only of limited interest in the social sciences. What is more, truly integrated assessments of marine social-ecological systems require interdisciplinary collaboration between the social and natural sciences, which is challenging for various reasons. However, integrated modeling provides a unique opportunity for such collaboration, which is urgently needed in the context of global social and ecological change. In this talk I will discuss some of the challenges, limitations and opportunities of integrated modeling against the background of my own interdisciplinary research experiences in the Benguela region.

Workshop 3: Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change



Prof. Icarus Allen is a research scientist at the Plymouth Marine Lab, UK where he is Head of Science for Marine Ecosystem Models and Predictions. Not surprising therefore, his research focuses on marine ecosystem modelling and he is involved in a number of NERC and EC FP7 projects.

Icarus' scientific background is multidisciplinary, specialising in the numerical modelling of marine systems from individual cells to shelf wide ecosystems. Until recently, the overriding theme of his work has been the interfacing of biogeochemical process models with hydrodynamic models in 1, 2 and 3 dimensions and the analysis of the subsequent simulations. In general terms the focus of this work has been the coupled physical biogeochemical modelling of shelf seas. More specifically this involves; operational ecosystem forecasting to develop operational plankton/ water quality forecasts, data assimilation and merging model/EO data products to predict HABs, model skill assessment, shelf seas ecosystem response to multiple drivers, both climate and anthropogenic, development of global shelf seas ecosystem models based on POLCOMS_ERSEM and the process modelling of climatically active marine biogases.

Abstract

INTEGRATED MODELLING OF ECOSYSTEM RESPONSE TO CLIMATE CHANGE AND ANTHROPOGENIC PRESSURES

Marine ecosystems provide a range of important services to mankind including food production, climate regulation through the cycling of carbon and other macronutrients, and a range of cultural values (e.g. recreation, tourism). They are in serious decline, primarily as a result of over-harvesting, pollution, and the direct and indirect impacts of climate change. Climate variability and change is interacting with other pressures to affect the productivity and dynamics of marine ecosystems, challenging managers charged with the sustainable stewardship of living marine resources. Dynamic models that link the physical, chemical and biological processes through food web interactions provide a means of understanding how human impacts on different parts of the ecosystem interact and of predicting the consequences of management actions in one sector on other sectors. Such predictive models allow the exploration of the impacts of both climate drivers such as acidification and temperature, and human induced drivers like fishing, invasive species and pollution on marine ecosystems. This talk will illustrate of how such models can be applied to address such issues drawing on examples from the MEECE, QUEST and VECTORS projects. The strength and limitations of these approaches will be discussed and recommendations for future work made.

Workshop 4: From regime shifts to novel systems – evaluating the social-ecological implications of lasting ecosystem changes for resource management



Dr. Scott Ling is a Marine Ecologist from the Institute for Marine & Antarctic Studies (IMAS) University of Tasmania. Scott's research spans a broad range of marine ecological investigations with a strong focus on *in situ* sub-tidal surveys and experimental manipulations on temperate reef ecosystems, involving more than 1600 research dives over the past 16 years. His research has become more global in scope and now extends into tropical systems as he seeks to understand the nature of reef ecosystem dynamics across progressively larger scales. His has focused on

investigating the effects of increasing, but ostensibly manageable, human stressors on marine ecosystems such as fishing, climate change, increasing urbanisation and the introduction of invasive species. Fundamental to his research approach is the identification of alternative ecosystem states and processes influencing shifts to less desirable states, particularly those that prove to be difficult to reverse.

Abstract

AN OUNCE OF PREVENTION CAN BE WORTH A TON OF CURE FOR MANAGING MARINE REGIME SHIFTS

Conceptual models of regime shift are well developed and the threat of global tipping points are increasingly cautioned, however the dynamics of ecosystem collapse and recovery are difficult to observe in nature. While there are increasing attempts to map observed ecosystem dynamics to the 'metaphors' of regime-shift theory, the ability to discern the dynamics of critical transitions, including potential hysteresis, seemingly rests on few amenable and well-studied natural systems. One such tractable system in the marine environment is the undesirable and persistent regime-shift observable for temperate reef ecosystems as a result of sea urchin overgrazing of productive kelp bed habitats. In this presentation, I will present key findings from local, regional and global scales regarding the regime-shift dynamics underpinning 'catastrophic' urchin grazing, which includes an estimated order of magnitude difference, i.e. hysteresis, between collapse and recovery thresholds in urchin biomass. The role of multiple human stressors such as ecological overfishing, climate change and urbanisation, plus stabilizing biological feedbacks conferring resilience of alternative regimes, are also explored and these lessons are considered holistically from temperate to tropical reefs and pelagic systems. Importantly, our collective understandings of marine regime-shifts will improve with ongoing collection of long-term data sets and direct *in situ* manipulations (where possible) in combination with the co-development of non-linear ecosystem models and ultimately early-warning tools signalling pending collapse and the 'window for action' before it is too late. This type of research is imperative for attempts to manage ecosystems for maximum social and ecological benefit and is particularly urgent given an increasing intensity and frequency of human-derived stressors which appear to be eroding resilience and exacerbating the risk, spatial extent and irreversibility of unwanted regime-shifts from local to global scales.

The poster sessions & mentoring programme

The poster sessions

There are two plenary poster sessions - on Tuesday and Wednesday evenings (17:30 – 20:00).

Participants with surnames from A – L will present their posters at the first poster session (27 October), and the remainder (M-Z) at the second session (28 October).

Posters will be displayed outside Budinich Hall. They will be arranged by workshop, but not in any specific order, so feel free to display your poster on any board allotted to your workshop.

Participants are responsible for displaying and removing their own posters. Please ensure that your poster is up by 17:00 on the day that you are presenting it, and taken down by morning tea time the next day.

Mentoring programme

As part of the IMBIZO IV mentoring programme, students and early-career researchers who requested a mentor, when they registered for the IMBIZO, were matched with more established researchers working in a similar field. Mentors provide advice on research ideas, assist with fine-tuning conference presentations, and most importantly help with networking at the IMBIZO.

There will be a "lunch with scientists" on Wednesday, where two or three established researchers will have lunch at a reserved table with some of the mentees to allow them to broaden their network a little more.

Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)



IMBER is an international project, co-sponsored by IGBP and SCOR, that aims to provide increased understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the earth system and human society.

East China Normal University (ECNU)

ECNU is a key university under the Ministry of Education of the People's Republic of China. The University has 21 schools and colleges and six research institutes that offer undergraduate programs in humanities, education, science, engineering, economics, management, philosophy, psychology, law, history and art, as well as post-graduate and post-doctoral programs.



European Space Agency (ESA)



ESA is Europe's gateway to space! ESA is an intergovernmental organisation, created in 1975, with the mission to shape the development of Europe's space capability and ensure that investment in space delivers benefits to the citizens of Europe and the world.

By coordinating the financial and intellectual resources of its members (22 Member States), ESA can undertake programmes and activities far beyond the scope of any single European country. ESA develops the launchers, spacecraft and ground facilities needed to keep Europe at the forefront of global space activities. Today, it launches satellites for Earth observation, navigation, telecommunications and astronomy, sends probes to the far reaches of the Solar System and cooperates in the human exploration of space.

EuroMarine

EuroMarine is a European, marine science network launched in 2014. It is a bottom-up organisation designed to give voice to the entire European marine scientific community. The initiative follows the experience of three former European Networks of Excellence (NoEs): EUR-OCEANS, MARINE GENOMICS EUROPE, and MARBEF.



Sponsors

Institute of Marine Research (IMR)

IMR is Norway's largest centre of marine science. Its main task is to



provide advice to Norwegian authorities on aquaculture and the ecosystems of the Barents Sea, the Norwegian Sea, the North Sea and the coastal zone. The aim of the research and management advice provided by IMR is to ensure that Norway's marine resources are harvested in a sustainable way. The IMBER International Project Office is hosted by the IMR, at its headquarters in Bergen.

Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO)



IOC-UNESCO established in 1960 as a body with functional autonomy within UNESCO, is the only competent organization for marine science within the UN system.

The purpose of the Commission is to promote international cooperation and to coordinate programmes in research, services and capacity-building, in order to learn more about the nature and resources of the ocean and coastal areas and to apply that knowledge for the improvement of management, sustainable development, the protection of the marine environment, and the decision-making processes of its Member States. In addition, IOC is recognized through the United Nations Convention on the Law of the Sea (UNCLOS) as the competent international organization in the fields of Marine Scientific Research (Part XIII) and Transfer of Marine Technology (Part XIV).

Ocean Carbon & Biogeochemistry (OCB)

The USA-based OCB program focuses on the ocean's role as a component of the global earth system, bringing together research in geochemistry, ocean physics and ecology to inform and advance understanding of ocean biogeochemistry. The program goals are to promote, plan and coordinate collaborative, multidisciplinary research opportunities within the USA research community and with international partners.



The OCB is supported by the NSF, NASA and NOAA in the USA.

Sponsors

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS)



OGS (National Institute of Oceanography and Experimental Geophysics) is an internationally oriented public research institution. This institution operates and develops its own mission in the European Research Area (ERA) and internationally, prioritizing the basic and applied research fields of:

- Oceanography (under the Physical, Chemical and Biological aspects);
- Geophysics and Marine Geology;
- Experimental and Explorative Geophysics.

OGS applies its own expertise in Earth Sciences, and in Marine and Polar regions to contribute not only to the spreading and widening of the knowledge, but also to the practical solution of environmental, economical and social issues in line with the National Program of Research (PNR) and strategic objectives set by the EU, with particular referral to Horizon 2020.

Scientific Committee on Oceanic Research (SCOR)

SCOR is an interdisciplinary body whose activities promote international cooperation in planning and conducting oceanographic research, and solving methodological and conceptual problems that hinder research. SCOR provides a mechanism to bring together international scientists and has thus been instrumental in the planning and coordination of several large-scale ocean research projects for long-term, complex activities.



State Key Laboratory of Estuarine and Coastal Research (SKLEC)



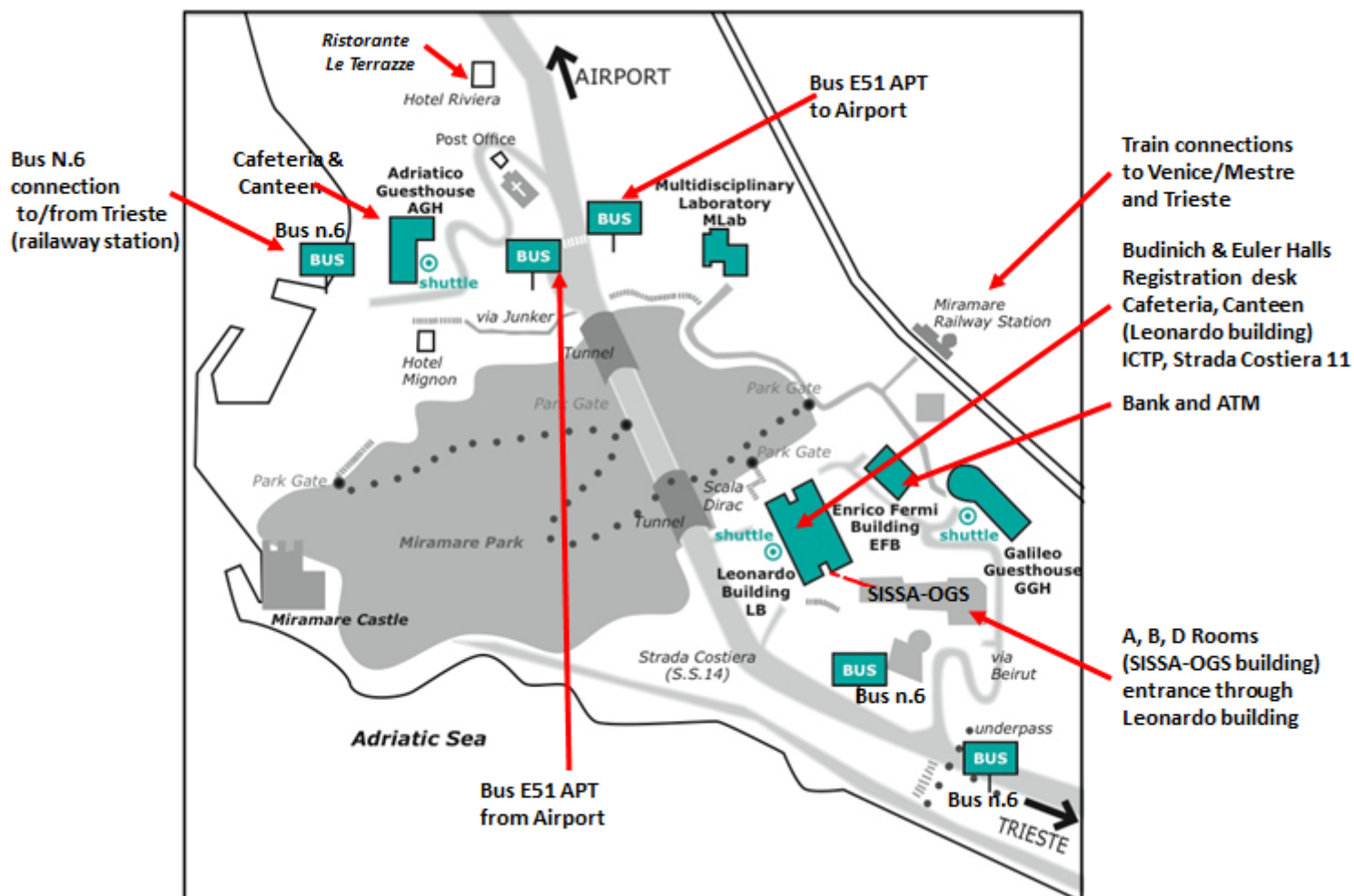
SKLEC is based at the ECNU in China. Its research areas include: estuarine evolution and sediment dynamics, coastal dynamical geomorphology and sediment processes and estuarine and coastal ecology and environment.

Meeting logistics

The venue for IMBIZO IV is

Leonardo Building (see the map below)
International Centre for Theoretical Physics (ICTP)
Strada Costiera 11
34151 Trieste Italy

Registration will take place in the lobby of the Leonardo Building



IMBIZO dinner venue

Ristorante Le Terrazze
22 str. Costiera,
34151 Trieste

All IMBIZO IV participants are invited. Two glasses of wine or beer will be served with your meal. Any additional drinks are available for purchase.

Practical information

Banking

There is a branch of UniCredit Banca on the Ground Floor of the Enrico Fermi Building (ICTP Campus) that is open from 08:30 - 12:30, Monday - Friday

There is an ATM outside the bank's main door.

Tipping

Tipping is optional in Italy, though it is often customary to round up a bill in a café or restaurant.

Emergency information

112 - Carabinieri

113 – Police

115 – Fire

118 – Ambulance

040 3991111 – Hospital

040 307730 – Radio taxi in Trieste

040 390039 – Taxi in Trieste

Where to eat in Trieste

The cuisine of Trieste reflects the traditions of the many populations that have passed through the city over the centuries. In the city's restaurants, called "buffets", you can find delicious examples of the local Austrian and Slavic tradition. Buffets are restaurants that serve typical dishes, usually sandwiches, with pork of varying types, mustard, and some grated horseradish (kren); sometimes also breaded zucchini or eggplant.

Useful words:

- **Caldaia:** traditional dish of boiled pork
- **Jota:** a soup prepared with pork, potatoes, cabbage and finely-ground beans
- **Gnocchi** in the style of Austrian dumplings, made with everything from ham to stuffed with plums
- **Brodetto:** fish soup
- **Sardoni in savor:** flavored pilchards

Restaurants:

Pizza and burgers:

- Pizzeria Al Barattolo, Piazza S. Antonio Nuovo 2 (Pizza) \$\$
- Pizzeria Peperino (19 v. Coroneo) \$\$
- 040 social food (8 v. Rossini) \$\$
- Pizzeria D Napoli (10 v. Diaz) \$\$
- Pizzeria Marinato (4 Riva Nazario Sauro) \$\$
- Genuino (13 via delle Beccherie) \$\$
- Birreria Forst (14 Riva Nazario Sauro) \$\$

Typical buffets:

- Trattoria da Giovanni (14 v. S. Lazzaro) \$
- Buffet da Pepi has been in operation for over 120 years (Via della Cassa di Risparmio) \$\$

Fish:

- Trattoria Nerodiseppia (23 v. Cadorna) \$\$\$
- Buffet da Angelina (14 v. Cadorna) \$\$
- Antico Panada (8D v. Rossini) \$\$
- Ristorante Citta' di Cherso (6 v. Cadorna) \$\$\$
- Ristorante Menarosti (Via del Toro n° 12) \$\$\$
- Al Fiori (Piazza Hortis n° 7) (fish) \$\$\$
- Navigando (6 Riva Nazario Sauro) \$\$

Workshop 1: Governance

Workshop 1: Marine ecosystem-based governance: From rhetoric to reality		
Tuesday, 27 October		
Time	Speaker	Title
08:30 - 09:30	Welcome by IMBIZO co-conveners, and dedication of IMBIZO IV to K.K. Liu	
09:30 -10:05	Silvia Salas	Let's cooperate: the first step in marine ecosystem-based governance
10:05 -10:40	William Chueng	Impacts of global change on coastal upwelling ecosystems and fisheries
10:40 -11:00	<i>Morning Tea</i>	
11:00 -11:35	Icarus Allen	Integrated modelling of ecosystem response to climate change and anthropogenic pressures
11:35 -12:10	Barbara Paterson	Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change – a social science perspective
12:10 -12:45	Scott Ling	Marine and human systems: Addressing multiple scales and multiple stressors
12:45-14:30	<i>Lunch</i>	
14:30-15:45	Conveners	Introduction of the workshop and participants Discussion about the 'white paper'
15:45-16:15	<i>Afternoon tea</i>	
16:15-16:35	Donata Melaku Canu	Elements of unsustainability in complex socio-ecological systems: lesson from failure in managing clam farming in the Venice Lagoon and the need for a resilience-based approach
16:35-16:45	Samiya Selim	What do we want from our Seas?
16:45-16:55	Yuri Artioli	Marine ecosystem models for ecosystem-based management: has their time arrived?
16:55-17:30	Discussion	
17:30-20:00	Poster session and icebreaker	

Workshop 1: Governance

<u>Wednesday, 28 October</u>		
Time	Speaker	Title
09:00-09:20	Alida Bundy	Confronting Change: development of an interdisciplinary support tool to triage human response to marine resource crises
09:20-09:30	Jorge Tam	Adaptation to the impacts of climate change on Peru's coastal marine ecosystems and fisheries
09:30-09:40	Annette Breckwoldt	Participatory coastal and marine management? People, reefs and fish in an Indonesian Archipelago
09:40-09:50	Tesu Sato	Transdisciplinary approach with artisanal fishers and traders in Lake Malawi for collaborative coastal resource management
09:50-10:30	Discussion	
10:30-11:00	<i>Morning Tea</i>	
11:00-12:30	Ratana Chuenpagdee	World Café: Learning to adapt: Interactive and participatory responses to global change
12:30-14:00	<i>Lunch</i>	
14:00-14:20	Henrik Österblom	The ecosystem approach – from a political ambition to a practical paradigm shift
14:20-14:30	Elena Gissi	How to apply an ecosystem-based approach to Maritime Spatial Planning. Mapping cumulative impacts in the Adriatic and Ionian Macroregion
14:30-14:40	Stefan Koenigstein	Participatory modeling of ocean acidification and warming impacts on a sub-Polar marine system to identify adaptation options
14:40-14:50	Cosimo Solidoro	Ecological impact, economic value and socio-ecological sustainability of mussel aquaculture in the Gulf of Trieste, Italy
14:50-15:30	Discussion	
15:30-16:00	<i>Afternoon tea</i>	
16:00-17:30	Plenary integration session	
17:30-20:00	Poster Session (Drinks and snacks)	

Workshop 1: Governance

Thursday, 29 October		
Time	Speaker	Title
08:30-09:00	Plenary report back session	
09:00-09:20	Astrid Jarre	Trust building, social learning and mediated management strategy evaluation in support of structured decision making in social-ecological systems of the southern Benguela
09:20-09:30	Hannah Bassett	A framework of frameworks: mapping the relationships between fishery assessment tools and assessing their potential to work together
09:30-09:40	Hans Ruperti Loor	The governance of small-scale fisheries from the point of view of the self-regulation strategies add local organization
09:40-09:50	Ranjani Panchang	Legislative amendments in ore handling practices improve fish catch: effect of estuarine monitoring
09:50-10:30	Discussion	
10:30-11:00	<i>Morning Tea</i>	
11:00-11:10	Alida Bundy	Fisheries, the inverted food pyramid and food security
11:10-11:20	Elisa Ravagnan	AQUAACCEPT: A multidisciplinary approach for a sustainable aquaculture development
11:20-11:30	Fabio Florentino	Fisheries management plans in the Mediterranean. How can we move from a rhetoric to a real governance?
11:30-11:40	Jeremy Pittman	Navigating the transition to ecosystem-based approaches to coastal governance in the Lesser Antilles
11:40-11:50	Robert Blasiak	Public perceptions of marine ecosystem services in the USA
11:50-12:30	Discussion	
12:30-14:00	<i>Lunch</i>	
14:00-14:10	Annalisa Franzo	Ecosystem functioning approach as a tool for sustainable management of contaminated areas
14:10-14:20	Angel Moran	Using ecological indicators for assessing the trawl shrimp fishery in Veracruz, Mexico

Workshop 1: Governance

14:20-14:30	Jamie Tam	Evaluating the ecological state of multiple ecosystem using indicator-based thresholds
14:30-14:40	Sylvia Setubal	Construction of a computerized system of fisheries management - GIS FISHING - for artisanal fisheries in Tocantins, Brazil
14:40-14:50	Fabio Pranovi	An assessment of permanent trawl fishery closures effects in the Northern Adriatic Sea
14:50-15:30	Discussion	
15:30-16:00	<i>Afternoon tea</i>	
16:00-17:30	Plenary interaction session (Debate)	
19:30	<i>IMBIZO Dinner</i>	

Friday, 30 October	
08:30-09:00	Plenary report back session
09:00-10:30	Drafting the 'white paper'
10:30-11:00	<i>Morning Tea</i>
11:00-13:00	Plenary wrap up

Poster:

Rajani Panchang	Proxy records for human-climate interactions over the past century offer clues for management policies in Central Indian Estuary
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ELEMENTS OF UNSUSTAINABILITY IN COMPLEX SOCIO-ECOLOGICAL SYSTEMS: LESSON FROM FAILURE IN MANAGING CLAM FARMING IN THE VENICE LAGOON AND NEEDS FOR A RESILIENCE BASED APPROACH

Melaku Canu D. & Solidoro C.

This paper explores reasons for the failures in managing socially and environmentally sustainable activities within a changing and complex socio-ecological system using, as an example, natural resource exploitation in the Venice Lagoon. A comparison with a simpler lagoon and with past Venice history highlights the need to balance efforts in the economic, environmental and social aspects of management, to reduce the fragmentation of social and governance components and to promote a co-management structure that includes adaptive and participatory approach elements. The availability of scientific knowledge to support decision making appears important but less limiting. Globalization often acts in the opposite direction, by altering regulatory mechanisms internal to the system and between the system and the external world and by inducing fragmentation in the social components of systems, eventually eroding SES resilience and favoring shifts to regimes of low environmental management and awareness, with cascading consequences to nested socioeconomic subsystems.

WHAT DO WE WANT FROM OUR SEAS?

Selim S.A. & Webb E.T.

Coastal ecosystems provide vital suites of Ecosystem Services (ES) to local communities, visitors, and wider society. For instance, they act as a source of food (fisheries), employment (fishing and tourism sectors) and recreation (e.g. tourism, wildlife-watching.) The relative contribution of these different ES to the suite of ES provided by a given coastal system will clearly change over time, as both societal priorities and ecosystem state change. Thus, using the suite of ES provided by a study system now (or in the recent past) to define 'good environmental status' and to drive management decisions risks excluding from consideration ES which were important in the past. Just as the phenomenon of 'shifting baselines' can cloud our understanding of ecological change, so it may distort the priorities of management for 'optimal' ES provision. In recent years there have been studies on identifying, characterizing, and valuing coastal ecosystem services and several of these studies have informed and have been integrated into management practices and policies such as the Millennium Ecosystem Assessment (MEA, 2005), Ecosystem Based Management (EBM) and Marine Strategy Directive Framework (MSDF)(Directive 2008/56/EC.) Whilst ecosystem services such as provisioning, regulatory and supporting have been mostly integrated into ecosystem approach (EA) frameworks, there has been a lack of integration when it came to cultural ecosystem services (CES). In this study we add to literature on CES and how it is linked to the state of the marine ecosystem. We do this by exploring the Yorkshire coast of Northeast England as a case study and outline how past, current and future ES provision is linked to historical ecological and socio-economic variables in this study site. We conducted 200 interviews with various stakeholders – fishermen, tourists and residents -to identify how CES is linked to marine biodiversity in a system.

MARINE ECOSYSTEM MODELS FOR ECOSYSTEM-BASED MANAGEMENT: HAS THEIR TIME ARRIVED?

Artioli Y., Cazenave P., Ciavatta S., Fernandes J.A., Heard J., Kay S., Papathanasopoulou E., Saux-Picar, S., Torres R., Wakelin S., Allen J.I.

Marine ecosystem models are theoretically the perfect tool to support ecosystem-based management of the marine environment. They are able to (i) integrate many components of the ecosystem (from physics to fishes to humans), (ii) describe the state of the system with a coverage not feasible by monitoring programmes, (iii) provide estimates for quantities that are not easily measurable (e.g. trophic fluxes) and coherently summarize information into useful indicators, (iv) forecast future conditions of the marine environment and (v) assess the impact of global changes from anthropogenic activities and policy/management implementation on the ecosystem. Furthermore, these models provide critical information used in socio-economic analysis to quantify and value the ecosystem services provided by the sea.

Despite all of the above, these models have not yet succeeded in being widely used by policy makers and regulators to inform their decisions for multiple reasons: (i) validation of models has often been rather qualitative decreasing their perceived reliability; (ii) similarly, limited information on the uncertainty of simulated present states and future projections makes such results incompatible with the risk analysis process typical of management decision making; (iii) computational constraints lead to a resolution generally too coarse for many management issues; (iv) a lack of dialogue between scientists and regulators brought to develop models generally more focused on the scientific aspects (e.g. long term projections, curiosity driven scenarios, complex indicators) rather than the more directly relevant to management (e.g. short term forecast, realistic policy scenarios, simple indicators).

Drawing from a series of recent and ongoing projects (e.g. MEECE, OPEC, UKOA, ROSA), we will show how marine ecosystem models have reached a stage of maturity that can provide useful information to management decision making, and how they can be efficiently promoted to regulators.

CONFRONTING CHANGE: DEVELOPMENT OF AN INTERDISCIPLINARY SUPPORT TOOL TO TRIAGE HUMAN RESPONSE TO MARINE RESOURCE CRISES

Bundy A., Perry R.I., Guillotreau P., Chuenpagdee R., Allison E., Defeo O., Glaeser B., Isaacs M., Li Y.

Globally, marine ecosystems are under a range of threats and pressure, including over-exploitation, that require an holistic approach considering the natural, social and governing systems. I.e., the full inclusion and consideration of humans as an integral part of the ecosystem. Understanding the linkages between marine ecosystem structure and functioning and human activities is critical to enable the selection of appropriate social and governing responses to threats to marine ecosystems and their dependent communities. To date, there have been few attempts to develop a structured approach to review and understand what social and governing responses are effective (or not effective) and in what contexts. Using the IMBER-ADApT (Assessment based on Description and responses, and Appraisal for a Typology) framework, we describe the development of a typology of marine resource crises and human (governance) responses. Using case studies detailing the natural, social and governing context, we describe how they can be used (1) as a simple inventory of crises, and the governance responses and (2) to develop a typology that identifies and groups similar crises, human contexts, and responses. We discuss the key characteristics that might be used as 'entry points' into the inventory and show how these can be used to develop the typology. The goal is to produce an operational interdisciplinary tool to assist and guide cost-effective policy and governing responses to marine resource crises that allows users to quickly identify which responses have worked (or not), and why, in similar situations elsewhere.

ADAPTATION TO THE IMPACTS OF CLIMATE CHANGE ON PERU'S COASTAL MARINE ECOSYSTEMS AND FISHERIES

Tam J. & Gutierrez D.

Current multidecadal trends inshore and offshore the Peruvian coast (e.g. warming in the north and coastal cooling in the central/southern regions) and first regional climate change scenarios support the view that significant shifts in water masses distribution, coastal upwelling fertility and stratification/mixing will likely occur in the next decades. Concomitantly the resource provisioning for the fisheries should be affected, due to impacts on the recruitment success of upwelling species, and on the distribution and catch potential of nektonic and benthic resources. The coastal ecosystems' vulnerability is amplified by non-sustainable fishing practices, pollution issues and the limited monitoring, prediction and management capacities of the administration at different levels. Therefore a program was designed in order to reduce the vulnerability of coastal marine ecosystems, fisheries and artisanal fisher communities to climate change. The program has two main components: a) interventions to increase the ecosystems' resilience, through the adoption of sustainable fishing practices, restoration and co-management of natural banks, as well as to increase the income of artisanal fishers through economic diversification and training on aquaculture and ecotourism activities; and b) development of a modern surveillance and prediction system of climate and environment, supporting fisheries activities and fisheries adaptive management. These components are complemented by measures for capacity building and knowledge dissemination, as well as by improvement of governance and management at regional and central levels. The first stage of the program is funded by the IADB and is focused on a pilot area representative of the Coastal Upwelling Ecosystem. A second stage of the program is under consideration by the Adaptation Fund and extends the interventions to a pilot area in the Northern Tropical Coastal Marine Ecosystem.

PARTICIPATORY COASTAL AND MARINE MANAGEMENT? PEOPLE, REEFS AND FISH IN AN INDONESIAN ARCHIPELAGO

Glaser M., Breckwoldt A., Ferse S., Baitoningsih W., Deswandi R., Radjawali I.

This paper arises from a three-year Indonesian-German research cooperation on the governance and management of Indonesian coastal and marine ecosystems. Project objectives were to investigate coastal and marine social-ecological dynamics and feedbacks and to analyze socio-political and institutional structures and processes to support adaptive coastal governance. Participating researchers and students worked in the Spermonde Archipelago, off South Sulawesi, Indonesia between 2007 and 2010. Methods included ship-based research excursions and several classical surveys and anthropological, participatory research methods applied by an interdisciplinary social-natural science team. This paper summarises our findings and draws policy conclusions. Reef exploitation and local livelihoods (including fisheries and mariculture), social networks and hierarchies have been investigated to understand social vulnerability, resilience and marine resource governance in the face of environmental change. We then discuss Marine Protected Areas and participation in their establishment process, thereby focusing on local “rules-in-use”. Throughout the study, the attitudes and future visions of islanders on the state and management of marine resources were also recorded. A clear outline of major policy recommendations and further research challenges conclude this paper.

TRANSDISCIPLINARY APPROACH WITH ARTISANAL FISHERS AND TRADERS IN LAKE MALAWI FOR COLLABORATIVE COASTAL RESOURCE MANAGEMENT

Sato T., Pemba D., Nakagawa C., Rusuwa B., Kassam D.

Small scale fisheries and trade of fisheries products are of tremendous importance for coastal resource management and human well-being in marine and lacustrine fishing communities in developing countries. Small-scale fishers and traders depend on various fisheries resources to sustain and improve their livelihood in complex social-ecological systems undergoing rapid and unpredictable changes. They also play critical roles to provide affordable protein resources for local residents under poverty. Adaptive governance and co-management of fisheries resources and socioeconomic/cultural systems are required to manage fisheries resources and cope with various environmental and societal problems facing stakeholders. In order to support autonomous decisions and actions among fishers, fish traders and other actors to promote co-management of fisheries resources and ecosystems for their well-being, we implemented a transdisciplinary approach with a wide array of local stakeholders to produce practical knowledge sets in riparian communities of Lake Malawi, Africa. A series of informal deliberative dialogues was co-designed and conducted in 2013 and 2014 in four riparian communities with artisanal fishers, small-scale traders/processors, local chiefs, local tour-guides, women groups and fisheries extension officers to visualize their challenges and success stories. Depletion of fisheries resources, post-harvest losses and potential conflicts with tourism/conservation sectors were found to be their major challenges. We also identified innovative and successful actions emerging in these communities, including autonomous seasonally protected areas operated under strong leadership of local chiefs since 1950's, innovative smoking and value-added marketing systems in a traders group, and creation of a local tour-guide association with the potential to collaborate with fishers. The importance of co-creating mutual learning platforms with transdisciplinary scientists/experts to share innovative approaches among riparian communities and to co-produce knowledge and tools to galvanize autonomous actions is discussed in relation to adaptive transition pathways toward sustainable communities with improved human well-being.

THE ECOSYSTEM APPROACH – FROM A POLITICAL AMBITION TO A PRACTICAL PARADIGM SHIFT

Österblom H., Hentati-Sundberg J., Nevonen N., Veem K.

The ecosystem approach is an increasingly salient policy paradigm originating from a scientific understanding of the reality of complex social-ecological dynamics. Few case studies have however documented the process of moving from a traditional, top-down and sector based approach, to a multilevel, cross-sectoral and integrated ecosystem approach. We have investigated changes in Swedish national marine policies and practice between 2002 - 2014, by reviewing government documents, changes in legislations, institutional changes, pilot projects, as well as changes in science and public opinion. Major changes in policy and practice are stimulating the development of an ecosystem approach, and some outstanding challenges are identified. A recent change in the Swedish Parliament or future environmental crises can open up windows of opportunity that can enable a paradigm shift. We conclude that documenting and understanding national case studies of change in policy and practice can stimulate a sustainability transition towards an operational ecosystem approach at larger geographical scales.

HOW TO APPLY AN ECOSYSTEM-BASED APPROACH TO MARITIME SPATIAL PLANNING. MAPPING CUMULATIVE IMPACTS IN THE ADRIATIC AND IONIAN MACROREGION.

Gissi E., Appiotti F., Maragno D., Bianchi I., Musco F., Sarretta A., Menegon M., Vianello A., Lipizer M., Campostrini P.

A central challenge for using an ecosystem-based approach (EBA) to the spatial planning of marine areas is to balance diverse human uses of ecosystems without compromise environmental quality. The Directive 2014/89/EU establishing a framework for Maritime Spatial Planning and the Marine Strategy Framework Directive (COM 56/2008), the environmental pillar of the European Integrated Maritime Policy (IMP), suggest the use of an EBA to reach objectives of sustainable uses in the marine domain. Considering as central assumption of EBA that anthropogenic activities both affect the ecosystem and depend on it, management based on EBA should take into account the maintenance of ecosystem services. The paper presents the results from the first phase of the methodology proposed and implemented for the Adriatic and Ionian Macroregion under the framework of “ADRI-PLAN: ADRIatic Ionian maritime spatial PLANning”, financed by DG MARE. The project reflects on allocating anthropogenic uses in maritime space without altering the capacity of the ecosystems to provide services and maximizing the benefits deriving from marine resources.

The paper reports the analysis of cumulative impacts on the Adriatic and Ionian Macroregion, with respect to the sensitivities of the environmental components to pressures produced by maritime uses acquired through expert opinion survey. The analysis is performed considering the confidence on the sensitivities expressed by the experts. The results are discussed within the framework of the implementation of the MSFD, to assess and monitor ecosystems status and their capacity to sustain ecosystem services supply. Main gaps, barriers and bottlenecks are put in evidence, arising from ADRIPLAN as the first Mediterranean experiment of transboundary MSP, as well as research needs and gaps.

PARTICIPATORY MODELING OF OCEAN ACIDIFICATION AND WARMING IMPACTS ON A SUBPOLAR MARINE SYSTEM TO IDENTIFY ADAPTATION OPTIONS

Koenigstein S. & Goessling-Reisemann S.

Changing environmental drivers are anticipated to impact marine organisms with consequences for the provision of marine ecosystem services to human societies. We present a case study from the Barents Sea and Norwegian Sea, where climate-related shifts are already visible and impacts of ocean acidification are expected in the near future. We developed a social-ecological system dynamics model which links climate change scenarios to the response of marine ecosystems and to the use of ecosystem services by human societies, integrating both scientific results and stakeholder concerns in a participatory approach to enable improved governance of marine ecosystems. We engaged stakeholders from Norway and Russia through personal interviews, two local workshops, and online surveys, gathering knowledge and concerns about changes in marine ecosystems. This served to integrate human uses and to identify the societally most relevant ecosystem services in the region: fisheries, tourism and recreation, carbon uptake, and cultural and educational services. Based on stakeholder interests, a multi-species model structure was developed to incorporate scientific results on climate-sensitive processes and ecosystem elements relevant for providing services to society. The model incorporates ecophysiological effects of warming and acidification on early life stages of fish from laboratory and mesocosm experiments, to explore the resulting consequences for fish population and community dynamics. Other ecosystem elements relevant for ecosystem services, such as phytoplankton and zooplankton groups, marine mammals and seabirds, are dynamically linked through the food web. The model was used to let stakeholders evaluate potential ecosystem changes under climate change scenarios and identify adaptation options. The model makes use of both scientific results and stakeholder input, integrating environmental and anthropogenic drivers across different scales, and can serve as a practical tool for developing adaptation strategies that are informed both by knowledge about ecosystem dynamics and by societal uses and values.

ECOLOGICAL IMPACT, ECONOMIC VALUE AND SOCIO-ECOLOGICAL SUSTAINABILITY OF MUSSEL AQUACULTURE IN THE GULF OF TRIESTE (ITALY)

Solidoro C., Del Negro P., Libralato S., Melaku Canu D.

In order to assess the ecological impact, economic value and sustainability of mussel aquaculture in the Gulf of Trieste (Italy), we integrated results of field monitoring, labs experiments and socio-economical surveys into a suite of numerical models, for system level computation of mussel potential production, related energetic requirements, and nutrients budget. Models outputs were then combined with results of economical survey, and used to compute the ecological footprint, the energy balance and other sustainability indicators of the activity. Results represent a relevant contribution to coastal zone management, allows for evaluating possible interactions of mussels farms with other uses of the basin and permit the assessment of the ecological role of farming in the ecosystem. Results indicate that this mussel farming is fully sustainable, suggest the possibility of enlarging the activity without significant impacting ecosystem status. In spite of the our willingness to involve mussel farmer and the fact the study was a) promoted by local authorities and b) possibly relevant for management planning, a collaborative process among stakeholders was hampered by a number of problems, including lack of trust, competition, and diffidence. We argue that a stronger attitude of the funding agency in defining and maintaining a clearer subdivision of roles, duties and responsibilities among scientists, farmers, and governing bodies might favor a collaborative process among stakeholders and possibly lead to higher efficiency in the use of research results.

TRUST BUILDING, SOCIAL LEARNING AND MEDIATED MANAGEMENT STRATEGY EVALUATION IN SUPPORT OF STRUCTURED DECISION MAKING IN SOCIAL-ECOLOGICAL SYSTEMS OF THE SOUTHERN BENGUELA

Jarre A, Duggan G.L., McGregor E.S., Weller F.G.

Structured decision making in support of a systems approach to assessment and management of human activities in marine social-ecological systems requires the collaboration of a wider variety of stakeholders with often conflicting goals and objectives. Fisheries management in the southern Benguela large marine ecosystem additionally has to operate (i) in face of the challenges caused by pronounced poverty in some marine-dependent communities, (ii) in the legacy of the Apartheid regime, which has amplified mistrust in those communities, (iii) following an ecosystem regime shift between the mid-1990s and early 2000s, and (iv) under large scientific uncertainties related to warming marine ecosystems bordering the southern Benguela, and seemingly increased variability in drivers of ecosystem dynamics in the southern Benguela. We present three approaches along the dimension of conflict resolution to soft operations research which hold promise in addressing those challenges. The first one represents building of trust through joint data collection of ocean temperatures with inshore fishers and opening conversations around climate variability and change. The second highlights the process of social learning around the implementation of an ecosystem approach to fisheries in the small pelagics fishery through indicators assessing ecosystem pressures and state in a knowledge-based system. The third approach uses mediated, predictive systems modelling to integrate the knowledge of a diverse stakeholder group with broadly similar interests to counter fisheries assessment-type modelling in a situation of sparse data and imperfect understanding of system dynamics, in support of an improved balance of objectives around conservation of dependent predators and their food base versus jobs in marine-dependent human social subsystems. The relative merits of the approaches in contributing to improvements in managing human activities in the southern Benguela are discussed with specific reference to concrete achievements in the recent five-years, and their potential in the long term.

A FRAMEWORK OF FRAMEWORKS: MAPPING THE RELATIONSHIPS BETWEEN FISHERY ASSESSMENT TOOLS AND ASSESSING THEIR POTENTIAL TO WORK TOGETHER

Bassett H.R. & Allison E.H.

The field of fisheries science has been moving toward a more integrated view of fisheries as human-natural systems for the past three decades, particularly since the rise in popularity of the ecosystem-based management concept in the 1990s and 2000s. Since that time, researchers and managers have acknowledged (to varying degrees) the need for a greater breadth of fishery-related data, rather than relying solely on measures of stock performance to inform management decisions. With a variety of aspects of fisheries in mind, tools to assess fisheries have been developed, each providing its own particular suite of functions, differing by either focal topic, flexibility, applicability, or a host of other aspects related to its aim and process. As more tools are developed, filling specific niches, we in theory grow closer to a well-rounded set of tools in our cumulative fishery assessment tool box. The question we pose consists of three parts: 1) Do the extant assessment tools cover the scope and complexity of fishery systems allowing for a holistic understanding (i.e. are all relevant facets of a fishery covered by accessible tools)?; 2) How would the extant assessment tools best be used in coordination to inform successful management?; and 3) Are the tools currently being used according to this idealized construct and if not, what critical gaps exist that inhibit the harmonious process from science to policy? Through description of the vital aspects of each tool (e.g. data collection methods, intended use, required software, etc.) and a scoring of its critical functions (e.g. flexibility, precision, experience required, etc.) an overview and comparison of relevant assessment tools will be presented. This analysis combined with a mapping of the relationships amongst tools and within the greater system will be presented to answer these challenging and important questions.

THE GOVERNANCE OF SMALL-SCALE FISHERIES FROM THE POINT OF VIEW OF SELF-REGULATION STRATEGIES AND LOCAL ORGANIZATION

Ruperti Loor H. & Castro J.J.

In Ecuador the artisanal fishing activity is a major source of economic livelihood and social safeguard for coastal dwellers. This fishery is characterized by a very heterogeneous fleet, the use of different fishing gear, uncertainty concerning the number of people taking part in this activity, and a lack of consistency in management policies. Understanding and assessing the contributions from both social and institutional agents is likely to lead to an improved management of the fisheries.

The aim of this work is to describe and evaluate the participatory processes involved in the bottom-up fisheries management in coastal Ecuador. The methodology uses secondary and primary sources of information. On-site tasks were performed using participation dynamics and workable linkages between authorities and fishermen.

This information provides invaluable insight into how the decentralized model of the fisheries management works, especially in terms of its economic performance, cost structure, and level of fishing effort. The formation of the Participatory Management Boards, an active and continuous interaction between local and national stakeholders, and the application of mechanisms for interagency governance are the most important actions implemented in order to enhance the management and participatory processes in this small-scale fishery. These insights has made it possible to implement fishery management strategies that now incorporate agreed actions with regard to organization and local self-regulation.

LEGISLATIVE AMENDMENTS IN ORE HANDLING PRACTICES IMPROVE FISH CATCH: EFFECT OF ESTUARINE MONITORING

Panchang R. & Nigam R.

Till very recently, open cast mining for iron and manganese was a major, and 100% export oriented industry of Goa, a major port of India. The mining reject stored in huge dumps is washed into nearby water bodies especially during monsoons, and eventually the estuaries, grossly increasing their total suspended load and turbidity. Thus, the two major estuaries of Mandovi and Zuari of Goa, along the Central west coast of India were monitored for environmental impact due to mining pollution.

Foraminiferal content of the Mandovi and Zuari Estuaries was studied in 2004 and compared with the 30 year old data. The study showed a decline in foraminiferal abundance and diversity with a gradual increase in suspended load in the Mandovi estuary. At the same time suspended load had reduced in the Zuari estuary and thus the foraminiferal abundance and diversity has increased manifold. Thus benthic foraminifera were effectively used as reliable proxy for both, progressive and retrogressive mining pollution in marine environments.

The present study demonstrated the potential of an ecosystem to recover if the right management practices were adopted. This led to the State authorities to make legislative amendments in handling, storing and transportation of mining ore and rehabilitation of mining land in the state. Reduction in suspended load has led to improved benthic production and improved fish catch, promoting sustainable development of both industries.

FISHERIES, THE INVERTED FOOD PYRAMID AND FOOD SECURITY

Kolding J., Bundy A., van Zwieten P.A.M., Christensen V., Law R., Plank M., Steenbeek J.

Fish are an important source of protein globally, accounting for 6.5 % of total protein consumed by humans, yet marine ecosystems are generally assessed to be overexploited and under productive. Here we demonstrate the extent to which this is the case with a global assessment of fishing patterns and fishing pressure from 129 different ECOPATH models, representing marine ecosystems throughout the world, and covering the period 1950 to 2007. Our results demonstrate that fisheries exploitation is highly unbalanced and skewed towards low productive species at high trophic levels, which are around two trophic levels higher than the animal protein we get from terrestrial systems. Overall exploitation levels from low trophic species was less than 15% of total production, and only 18% of the total number of exploited groups and species were harvested above 40% of their production, which is the general reference limit for sustainability. Generally, well managed fisheries from temperate ecosystems were more selectively harvested than tropical and upwelling fisheries, resulting in potentially greater long-term changes to the ecosystem structure and functioning. The results indicate a very inefficient utilisation of the marine production. Marine ecosystems have the potential to provide significantly increased overall catches while rebuilding overfished components, if the fishing regimes were changed towards more balanced fishing, potentially resulting in increased food security in many parts of the world.

AQUAACCEPT: A MULTIDISCIPLINARY APPROACH FOR A SUSTAINABLE AQUACULTURE DEVELOPMENT

Ravagnan E., Gjerstad B., Provan F., Fabi G, Hynes S., Agustsson T., Gomiero A., Gramolini R., Grøntvedt R., Krøvel A.V.

Aquaculture has grown rapidly worldwide in the past decades and will continue to grow to satisfy the rising food demand of an increasing world population. To match this growth in a sustainable way, several environmental as well as social challenges must be faced, including increased pollution, spreading of diseases and escape of farmed fish. The hostile perception of part of the society towards aquaculture activities, caused by conflicts between different users of the coastal areas (i.e., recreational fishing, tourism, other type of industries) must be addressed as well.

The AquaAccept project engages experts in several disciplines (biology, ecology, economy and sociology, computer sciences) to suggest solutions for the development of the aquaculture industry in agreement with society's views and the best use of environmental resources. Novel environmental indicators in aquaculture will be developed, to monitor the ecosystem status. The social acceptance for aquaculture will be studied to explore user-groups' priorities and potential conflicts of interests and a comparative studies will be performed in Norway and Ireland (as EU representative). The environmental and social findings will be merged in an innovative managing on-line application in order to evaluate spatial and/or temporal interactions existing in a specific marine coastal area.

A continuous and open dialog between the aquaculture industries, NGOs policy makers, general public and the scientific community is a basic requirement for the sustainable growth of the aquaculture industries. Local communities will be engaged in the dialogue, as well as industry representatives, local administrators and policy makers. Results from the project's first year will be presented and discussed.

FISHERIES MANAGEMENT PLANS IN THE MEDITERRANEAN. HOW CAN WE MOVE FROM A RHETORIC TO A REAL GOVERNANCE?

Fiorentino F. & Vitale S.

Sustainable exploitation of fisheries resources can be reached through the implementation of long term management plans (LTMPs). Within an ecosystem approach to fishery management, these plans must take into account the different dimension of fisheries, including ecological, social, economic and legal aspects. Taking into account this general framework, experiences gather in implementing ecosystem based approach and participation governance (Co-management) to fishery management in the Mediterranean were illustrated. In particular main aspects regarding the implementation of management plans for coastal fisheries in three different districts of western Sicily were presented and discussed, underlying main weakness and strength. According to the Authors the main critical points that impede an effective governance of fisheries in the area are: low sharing of information among the stakeholders, low leadership of fisheries organization, high level of illegal and unreported catches, high difficulties in access to funds and socio-economics measures, low clarity of different actors role in functioning of the LTMPs, low involvement of coastal guard and fishermen in monitoring, control and surveillance. Some ideas to move LTMPs from a rhetoric to a real governance of fisheries in the Mediterranean were finally presented.

NAVIGATING THE TRANSITION TO ECOSYSTEM-BASED APPROACHES TO COASTAL GOVERNANCE IN THE LESSER ANTILLES

Pittman J.P. & Armitage D.R.

This paper examines the role of multilevel networks in fostering or inhibiting the changes in coastal governance necessary to better implement ecosystem-based approaches to management and climate change adaptation in the Lesser Antilles. Multilevel governance networks are sets of organizations, stakeholder groups, and their relationships (e.g., the ways they coordinate or collaborate) across multiple levels of organization (e.g., local, national, regional) that mobilize to address certain issues or within a particular action domain. Our analysis draws on interviews with 96 individuals involved with coastal governance (e.g., government and non-governmental organizations, resources users, and business operators) across four case studies: Antigua and Barbuda, St. Kitts and Nevis, Grenada, and St. Vincent and the Grenadines. We analyzed interviews using a multi-method approach, which included social network analysis and qualitative content analysis. Our findings suggest that the roles of governance networks are often overlooked but that they influence capacities to implement ecosystem-based approaches in three main ways: (1) horizontal linkages at the national level provide a policy space conducive to ecosystem-based approaches; (2) vertical linkages between national and local level actors help close implementation gaps; and (3) horizontal linkages at the local level ensure synergistic efforts across projects and programs. These findings suggest that multilevel networks require significant local level steering to operationalize ecosystem-based management, but that national – and in some cases regional – coordination is also necessary when attempting to manage ecosystems across scales. The capacity to implement ecosystem-based management depends on how the interplay within and between networks at different levels facilitates local leadership while maintaining coherence at different scales.

PUBLIC PERCEPTIONS OF MARINE ECOSYSTEM SERVICES IN THE USA

Blasiak R., Ichikawa K. and Yagi N.

People's perceptions of the value of marine systems remain largely unknown. In some cases, researchers have calculated the benefits derived from the world's ecosystems using the four categories of ecosystem services defined in the Millennium Ecosystem Assessment, but fail to answer the question: "value to whom?" This question is highly relevant in the case of cultural services, and becomes particularly challenging to assess in the case of marine systems, where human linkages are arguably less tangible than in terrestrial systems. In this presentation, we will present the outcomes of a randomized survey of 1,434 residents of the USA focusing on marine ecosystem services. The survey encompasses three main areas: perceived indispensability of different marine ecosystem services, perceived current state of these marine ecosystem services, and readiness to take action (volunteering / donation / taxation, etc) to ensure the conservation and sustainable use of marine systems. During the presentation, statistical analysis of this dataset will be introduced, including surprising results related to homogeneity of respondents in both a regional and political sense. Furthermore, the analysis has indicated that age is strongly correlated with certain actions (e.g. taxation), and gender more weakly so. Furthermore, the results are suggestive of a prevailing perception of the oceans as a truly global commons, which suggests that readiness to act may have an altruistic rather than self-interested basis, at least over the short term. The presentation will cover further details of all these findings, and juxtapose them with the outcomes of a similar study conducted in Japan the same year.

ECOSYSTEM FUNCTIONING APPROACH AS A TOOL FOR SUSTAINABLE MANAGEMENT OF CONTAMINATED AREAS

Cibic T., Franzo A., Nasi F., Rogelja M., Auriemma R., Fabbro C. & Del Negro P.

The ecosystem approach to management (EAM) of the marine and maritime space remains still more of a concept which is widely discussed at scientific fora, but with very few examples of actual practice. To provide practical support to decision makers in the spatial planning of a harbour and/or highly polluted area, the EAM was applied to three Sites of National Interest, i.e. very large contaminated areas classified as the most dangerous by the Italian State and in need of remediation, one located in the lagoon of Grado-Marano, one in the port of Trieste (both in the northern Adriatic Sea) and one in the Mar Piccolo of Taranto (Ionian Sea).

To assess the ecosystem functioning, a holistic approach was followed by integrating the ecosystem structure, its functioning and biological diversity at several trophic levels in the sediments and also in the water column (only in the last study-case).

In the Grado-Marano lagoon we observed an extremely active microbial community at the most contaminated station that ensured high production and degradation rates, indicating an ongoing bioremediation process, resulting in a technical decision against the dredging of the area.

In the port of Trieste, according to our results, one part of the SIN should not necessarily have to be included in it, because there we observed a particularly biodiverse, structured and productive benthic community.

In the Mar Piccolo, in contrast, the sediments within the navy arsenal were so strongly polluted to reduce the abundance at all trophic levels and interfere with the proper functioning of the benthic ecosystem, indicating that the dredging of this particular area would be an appropriate intervention.

Our findings show how the correct assessment of the ecosystem functioning in polluted areas may represent a useful tool for their management to plan environmental interventions in a rational way.

USING ECOLOGICAL INDICATORS FOR ASSESSING TRAWL SHRIMP FISHERY IN VERACRUZ, MEXICO.

Morán S.A., Jiménez B.M.L, Cházaro O.S., Meiners M.C.G, Galindo C.G & Chávez L.R.

The shrimp fishery is the leading fishery in the Gulf of Mexico. The capture is obtained through trawling on the seabed, causing an impact on the ecosystem. Fishing takes place on the coast of Veracruz state between 19°23'N, 96°17'W and 18°19'N, 94°35'W. The objective of this study is to analyze, through the use of indicators, the shrimp fishery in Veracruz. The information was obtained from 75 research trawls National Fisheries Institute in June and July 2013 on the ship Inca V. Weight, total length and number of organisms was recorded by species with a commercial important, fishes and crabs. Discards weight was recorded and took a sample to identifying and registering fish abundance and weight by species, length of each organism and trophic level. The richness, Shannon-Wiener diversity and evenness were evaluated. Indicators were selected to record the effect of fishing on the ecosystem: Capture, by catch/Capture ratio, medium length, and Trophic Level. A total of 3113.51 ha. crawled, the proportion of shrimp catch with respect to by catch fauna was 1.91 to 4.37 kg and discard 5.79 to 9.94 kg was obtained. 62 species of fish and 21 species of crustaceans were identified. Frequency analysis size chart for the most abundant species was obtained. Trophic level varied from 3.79 to 3.86. Abundance, richness and diversity by trawl and depth interval was evaluated. These parameters are proposed as indicators for the evaluation of the fishery. Is inferred that there is an impact on the ecosystem and the communities that comprise it, which you can see reflected in the composition of the catch, the trophic level and range of sizes, as well as ecological parameters.

EVALUATING THE ECOLOGICAL STATE OF MULTIPLE ECOSYSTEMS USING INDICATOR-BASED THRESHOLDS

Tam J.C., Link J.S., Large S.I., Samhouri J., Hazen E., Andrews K., Kaplan I., Tolimieri N, Zador S., Karnauskas M., Gove J., Shuford R.

Ecosystem indicators have been used to evaluate ecological status in Large Marine Ecosystems (LMEs) and to develop decision criteria towards the implementation of Ecosystem-Based Fisheries Management (EBFM). When carefully chosen, ecosystem indicators can be highly adaptable and can provide insight into the ecological status of not only one, but many LMEs. Quantitative assessment of how ecosystem indicators can be used is an important step in influencing decision making and developing control rules to achieve balanced policy objectives and goals. Here we attempt to translate ecosystem indicators into decision criteria using quantitative methods to establish thresholds of indicators against multivariate environmental and anthropogenic pressures across LMEs from the US Pacific, Atlantic, sub-Arctic, Pacific Islands and Gulf of Mexico coasts. By using a suite of operational indicators that address varying aspects of ecological status in fisheries including size distributions, trophic dynamics, energy flow, community structure and total system production, we have developed a clear means of evaluating thresholds of system-wide responses to environmental and anthropogenic perturbations; this will lead to further development of control rules in implementing EBFM. We found that increases in environmental pressures can have both positive and negative effects on indicators depending upon the type and magnitude of the pressure. Our findings indicate that thresholds of ecosystem indicators tend to occur at similar locations in multivariate phase-space, and as such can delineate the combined impacts of environmental and anthropogenic pressures across multiple ecosystems. We discuss the extent to which these critical points can begin to be translated into ecosystem-level decision criteria.

CONSTRUCTION OF A COMPUTERIZED SYSTEM OF FISHERIES MANAGEMENT - GIS FISHING, FOR ARTISANAL FISHERIES IN TOCANTINS, BRAZIL.

Setubal S., Rodrigues A.B., Patricio Y., Doeler F.

The State of Tocantins is located in the northern region of Brazil and belongs to the Brazilian Amazon Forest. There are 35 professional artisanal fishing colonies distributed along the watershed basin of the Araguaia river -Tocantins. Nowadays the state productive artisanal fishing chain profile is unknown, being this one of the key aspects for the sustainability planning for the fishing activity. The fishing colonies have a very simplified administrative and management system, partly due to the low fishermen educational level. In this context, the project aims to build a Computerized System for the Management of Fishing (“FISHING GIS”) to be used by fishermen colonies and managed by the Ministry of Fishing and Aquaculture - MPA. The SIG Fishing was generated in a web based system with the PHP programming language, using the PostgreSQL database from forms already used by MPA in the general register of fishermen, environmental assessment protocols and morphometric data that are already used by experts from each area. The system will do, among others, records of administrative data from the associated Fishermen Colony, from production and marketing of the captured fish to the bioecology data of species and the environmental conditions in the fishing region. This tool will provide agility, efficiency and effectiveness in assessment and monitoring of fishery resources since it allows establish correlations of information entered into a database, contributing to the development of the sector in the State of Tocantins.

AN ASSESSMENT OF PERMANENT TRAWL FISHERY CLOSURES EFFECTS IN THE NORTHERN ADRIATIC SEA

Pranovi F., Anelli Monti M., Caccin A., Zucchetta M.

The increasing of human activities in coastal areas claims for the implementation of management approaches capable to cope with multiple-use conflicts. At present, fishing activities are recognized among the most important drivers affecting marine ecosystems, so playing an important role when defining marine management plans, mainly in relation to the reduction of fishing effort. Within this context, according to the Council Regulation (EC) nr. 1967/2006, since June 2010 the Italian government prohibited the trawling activity within three nautical miles from the coast or within the 50 m isobath. This decision was expected to deeply modify the trawl fishery sector, directly affecting catches. Here we reported the results of a first assessment of the ban effects on catches and its possible ecological and social implications on the North Western Adriatic Sea coast. Landings per Unit of Effort for each trawling fleet segment have been analysed, by comparing the before (2007-2009) and after ban (2011-2013) period. The comparison was carried out considering total landings and the six main species targeted inside the three miles area. Within a context of the general reduction of total landings, a differential effect based on the analysed métier was detected, with small trawlers being more negatively affected than the large and rapid ones, which showed, for some species, positive impacts. From an ecological point of view, though, no positive effects were detected, probably because the adopted measure is not sufficient to reduce the overexploitation. From a social perspective, all this is affecting the structure of the small-scale fishery in the area, with fishermen moving from the small trawling towards the artisanal fishery. The new situation will require, to be carefully managed in order to reduce the risk that an increase of the fishing effort on this activity would compromise the possible local benefits of the ban.

PROXY RECORDS FOR HUMAN-CLIMATE INTERACTIONS OVER THE PAST CENTURY OFFER CLUES FOR MANAGEMENT POLICIES IN CENTRAL INDIAN ESTUARY

Panchang R. & Bhushan R.

The Kundalika Estuary in the Central West Coast of India is earmarked for conservation by Indian Ministry of Environment and Forests. However, several threats to this ecosystem have been recently documented, the most deleterious being large scale sand-mining and release of untreated industrial waste. Continued depletion in fish resources and repeated episodes of mass-fish mortality has been attributed to climate change by government authorities and to industry by local population. Regulatory bodies monitoring pollution in the estuaries of west coast of Maharashtra express inability to assess damage to the ecosystem in absence of long term baseline data/pre-effluent data. Foraminiferal signatures in sub-surface sediment samples can give the best clues to environmental conditions during pre-effluent or pre-anthropogenic times. Additionally, because foraminifera occur at the base of the food chain, their spatial distribution is capable of providing signatures of pollution as a very early stage, before significant damage is done to any ecosystem. Thus, proxy data was generated on an 80-cm long sediment core (representing approximately the past century) collected in the lower Kundalika estuary. The study discusses foraminiferal data as clue to assess the impact of the human-climate interactions on the Kundalika. The downcore foraminiferal signatures are compared with the rainfall and temperature (climatic record) data as well as various anthropogenic developments, such as damming, establishment of industries, population, etc. The foraminiferal data synchronizes well with the rainfall data till about 1965. After 1965, the foraminiferal distribution follows the land-use land pattern change in the watershed of the estuary. The data provides concrete clues to depletion of the estuarine habitat and its causes. This data also offers reasoning to the depletion in coastal fish catch over the past two decades.

Poster presentation

Workshop 2: Upwelling

Workshop 2: Coastal upwelling ecosystems as models for interdisciplinary studies of climate and global change		
Tuesday, 27 October		
Time	Speaker	Title
08:30 - 09:30	Welcome by IMBIZO co-conveners, and dedication of IMBIZO IV to K.K. Liu	
09:30 -10:05	Silvia Salas	Let's cooperate: the first step in marine ecosystem-based governance
10:05 -10:40	William Chueng	Impacts of global change on coastal upwelling ecosystems and fisheries
10:40 -11:00	<i>Morning Tea</i>	
11:00 -11:35	Icarus Allen	Integrated modelling of ecosystem response to climate change and anthropogenic pressures
11:35 -12:10	Barbara Paterson	Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change – a social science perspective
12:10 -12:45	Scott Ling	Marine and human systems: Addressing multiple scales and multiple stressors
12:45-14:30	<i>Lunch</i>	
14:30-14:45	Workshop Conveners	Introduction to the workshop
14:45-15:05	Francisco Chavez	A comparison of eastern boundary upwelling systems: Revisited
15:05-15:25	Ken Drinkwater	CLIVAR-IMBER research initiative on upwelling
15:25-15:45	Aurélien Paulmier	Eastern boundary upwelling systems: a natural future earth priority
15:45-16:15	<i>Afternoon tea</i>	
16:15-16:35	Ryan McCabe	Reexamining flow across the continental shelf
16:35-16:55	Karolina Bohata	Upwelling filaments and its associated fauna: the micro-zooplankton community
16:55-17:15	Alberto Piola	A study of small-scale fisher people's perceptions of policies, resources and the fishing industry in Sri Lanka using Q-methodology in order to identify the root causes of current industry conflicts
17:15-17:35	Jaime Färber Lorda	Relationship between zooplankton distribution and hydrography in deep waters of the southern gulf of México
17:30-20:00	Posters and icebreaker	

Workshop 2: Upwelling

Wednesday, 28 October		
Time	Speaker	Title
09:00-09:10	Workshop Conveners	Introduction to the Day
09:10-09:30	Nina Bednaršek	Pteropods in the California Current System: Indicators for ocean acidification across different upwelling regimes
09:30-09:50	Nicolas Gruber	Biogeochemical extreme events in eastern boundary upwelling systems
09:50-10:10	James Ruzicka	Simulating effects of changing upwelling conditions across trophic levels within the Northern California Current
10:10-10:30	Yoshimi Suzuki	Ocean acidification: how real it is for coastal ecosystems?
10:30-11:00	<i>Morning Tea</i>	
11:00-11:20	Eddie Allison	Adapting as usual? Societal responses to long-term change in highly variable systems
11:20-11:40	Stacy Aguilera	Managing fisheries in upwelling ecosystems for adaptive capacity: insights from dynamic social-ecological drivers of change in Monterey bay, California
11:40-12:00	Monique Messié	Towards satellite-based indicators of climate-driven changes in the California current upwelling ecosystem
12:00-12:20	Open discussion	
12:20-12:30	Short wrap up session	
12:30-14:00	<i>Lunch</i>	
14:00-14:20	Dimitri Gutierrez Aguilar	Recent trends in the Peruvian Coastal Upwelling Ecosystem and climate change scenarios: challenges for adaptation
14:20-14:40	Ken Drinkwater	Upwelling in polar regions under climate change
14:40-15:30	Open Discussion	
15:30-16:00	<i>Afternoon tea</i>	
16:00-17:30	Plenary interaction session (Discussions)	
17:30-20:00	Poster Session (Drinks and snacks)	

Workshop 2: Upwelling

<u>Thursday, 29 October</u>	
08:30-09:00	Plenary report back session
09:00-09:15	Short Introduction of the day
9:15-10:30	Discussion about drafting a White Paper
10:30-11:00	<i>Morning Tea</i>
11:00-12:30	Continuation of discussion and drafting White Paper
12:30-14:00	<i>Lunch</i>
13:30-15:30	Drafting White paper
15:30-16:00	<i>Afternoon tea</i>
16:00-17:30	Plenary interaction session (Debate)
19:00	IMBIZO IV Dinner

<u>Friday, 30 October</u>	
08:30-09:00	Plenary report back session
09:00-10:30	Discussion
10:30-11:00	<i>Morning Tea</i>
11:00-13:00	Plenary wrap up

Poster:

Leslie Aveytua Alcazar	Modelling ocean-lagoon interactions in a sub-tropical coastal lagoon affected by upwelling
Elisabet Sane	Pigments as biomarkers of quality and origin of organic matter off the SE coast of Algarve, Portugal
Heather Benway	The US ocean carbon and biogeochemistry (OCB) program
Rolf Koppelman	Upwelling filaments and its associated fauna: The mesozooplankton community
Humberto González	Possible impacts of climate change on trophic carbon flow and ecosystem services in the southern Chilean Patagonia.
Eleuterio YÁÑEZ	Climate change and pelagic fisheries predictions in Chile: CLIPESCA

A COMPARISON OF EASTERN BOUNDARY UPWELLING SYSTEMS: REVISITED

Chavez F.P. & Messié M.

In 2009 we published a review comparing the four major coastal upwelling systems: Benguela, California, northwest Africa and Peru. Here we update the review with emphasis on recent developments and attempt to prioritize the challenges facing these systems in the future. While the four regions face multiple threats from climate and human pressure, each system presents its own unique challenges.

CLIVAR-IMBER RESEARCH INITIATIVE ON UPWELLING

Drinkwater K.F. & Curchister E.

CLIVAR, as part of their new research strategy, identified a small number of research topics they would like to focus on over the next 5 years or so and in which they felt significant progress could be made. Wanting to be relevant to potential users of their research, CLIVAR approached IMBER to join them in one of these endeavours in which they would conduct joint research into some mutual important aspect of biophysical interactions. They chose to investigate upwelling given the strategic importance of these regions. Biologically, they contain the most productive fisheries in the world's oceans while from the physical perspective they are of interest as sources of bias in global models, not only locally but also in far fields. Other important issues related to upwelling include changes in oxygen levels and potential hypoxia, causes of interannual variability in the amount of upwelling, the role of upwelling intensity on productivity, synchrony in fish catches within and across basins, and what will happen to upwelling rates under climate change. A small group of CLIVAR and IMBER researchers have been exploring some of these potential avenues of research on upwelling that this research initiative should investigate. In this talk we will present some of these possibilities, mention the initial activities of the group to date, and seek input from the audience as to the issues that they think this group should explore.

EASTERN BOUNDARY UPWELLING SYSTEMS: A NATURAL FUTURE EARTH PRIORITY

Paulmier A., Dewitte B., Illig S., Garçon V. & the SOLAS Scientific Steering Committee

The eastern boundaries of the tropical and subtropical oceans are characterized by high primary and export production that, in combination with weak ventilation, cause natural oxygen depletion and the development of oxygen minimum zones (OMZs) in intermediate waters. OMZs affect nearly all aspects of ecosystem structure and function in the water and on the sea floor. Economies of the countries neighbouring upwelling zones, which are largely reliant on adjacent marine resources for food and employment, urgently need improved capacity to predict variations in ecosystem structures and coastal water quality relating deoxygenation and acidification to define sustainable management strategies of their marine resources. The OMZs also play critical roles in atmospheric chemistry and climate through emission of active trace gases. These regions also feature extensive stratocumulus cloud decks that play a pivotal role on the Earth's radiation budget and thus in the response of the climate system to greenhouse gas forcing. Global climate IPCC models experience great difficulties simulating eastern boundary regions, exhibiting the most severe warm SST biases. Since 2009, the SOLAS project has launched a Mid Term Strategy Initiative on EBUS and OMZs and has held 3 international workshops (Peru, November 2010 and 2012 and EUR-OCEANS Conference, Toulouse, October 2011). We will present some major scientific findings achieved over the EBUS and the possible route for joining efforts in between Future Earth core projects to adopt an integrative approach coupling atmosphere, ocean, continents and socio-economic dimensions. There is a pressing need to improve the predictive capacities of regional coupled models considering the breath of interaction processes between atmosphere, ocean, biogeochemistry and land at the regional scale, and the limitations of global climate model in these regions. Coordinated multi-model experiments are vital to achieve this goal, as are enhanced ocean and atmosphere observations of the eastern boundary regions.

REEXAMINING FLOW ACROSS THE CONTINENTAL SHELF

McCabe R.M., Hickey B.M., Dever E.P., MacCready P.

We present moored observations of flows crossing the continental shelf in the northern California Current System, a highly productive Eastern Boundary upwelling system. Our focus is on the seasonally changing vertical structure of upwelling return flows. Shallower onshore flows can potentially lead to less upwelled nutrients, and this, in turn, may impact the structure of coastal ecosystems. Historically, analyses of such upwelling flows have met with mixed success because the upwelling circulation is typically an order of magnitude or more weaker than coincident alongshelf flows. Our analysis employs a streamwise-normal coordinate system to eliminate meander-induced biases in the cross-shelf flow that are unaccounted for with an alternative, commonly-applied approach. The resulting flow develops an organized pattern midway through the upwelling season. Under upwelling-favorable conditions an onshore return layer occurs just beneath the offshore surface flow, and a third offshore-directed layer exists at depth. Both subsurface layers strengthen in time. Mechanisms to explain this mean structure are evaluated, and it is suggested that the timing of the development and strengthening of both the interior return flow and the offshore near-bottom layer are consistent with the seasonally-changing direction and magnitude of the large-scale alongshelf sea level gradient. The change to a poleward sea level gradient initiates a seasonal relaxation of upwelled isopycnals that likely leads to the near-bottom flow. Late-season enhancement of the interior return flow is related to alongshelf winds but appears to form as a consequence of offshore transport in the near-bottom layer and the need to satisfy coastal mass balance. We suggest that coastal alongshelf pressure gradients are essential components of the coastal response that should be more routinely taken into account when analyzing coastal flows and their relationship to biogeochemical and ecosystem responses.

UPWELLING FILAMENTS AND ITS ASSOCIATED FAUNA: THE MICROZOOPLANKTON COMMUNITY

Bohata K., Koppelman R., Mohrholz V., Möllmann C.

Upwelling filaments are important components for dynamics of eastern boundary current regions and represent mechanisms for the transport of nutrients and plankton to the open ocean. They are able to transport a large fraction of coastal primary production even during low upwelling intensity. However, the dimension and nature of transported organic matter depends largely on the size structure of the involved plankton community. We investigated the importance of microzooplankton in an upwelling filament off the west coast of Africa at approximately 20°S in September 2013 using water bottle samples (20-200 µm) and 55 µm net samples (55-200 µm). The filament was located in the mixing and transition area of two different central water masses, the Eastern South Atlantic Central Water (ESACW) and South African Central Water (SACW). Clear small-scale differences in the distribution of some microzooplankton species were detected and related to the fractions of SACW and ESACW. High abundances of small and large microzooplankton fractions were observed at the southern front and in the upper layers of the filament centre. Surprisingly, low abundances of microzooplankton were found at the northern front of the filament which was probably a result of water circulation within the filament. Along the filament, the microzooplankton composition changed from ciliates-dominated in the in the centre of the filament to dinoflagellate-dominated further offshore. We hypothesize that a shift to more ciliates and heterotrophic dinoflagellates observed in the southern front could have an effect on the biogeochemical cycle as multiple steps within the microbial food web reduce the efficiency of transfer organic matter to higher trophic levels.

EVIDENCE OF UPWELLING AT THE NORTHERN PATAGONIAN SHELF BREAK

Valla D. & Piola A.R.

The Patagonian shelf break marks a transition between relative warm-fresh shelf waters and relative cold-salty Subantarctic Water advected northward by the Malvinas Current. From early spring to late autumn, the outer shelf region is characterized by a band of high chlorophyll concentration that sustains higher trophic levels, including significant fisheries. We analyze time series of current and water mass property observations collected at two moorings deployed at the shelf edge at 41 and 43.8 °S to investigate what mechanisms lead to temperature variability at the shelf break, and their role on the nutrient supply to the upper layer. Our results indicate that fluctuations of temperature and salinity are associated with the variability of the cross-shelf flow only at the tidal semi-diurnal frequency. The in-situ data are combined with satellite-derived observations of sea surface temperature and chlorophyll-a to analyze a sharp cooling event at the outer shelf that lasted ten days and extended ~ 500 km along the outer shelf. The event is consistent with upwelling of cold waters through the base of the mixed layer. The vertical velocity required to explain the observed cooling is 13 to 29 m·day⁻¹. Satellite derived sea surface temperature reveal additional cooling events of similar characteristics. Seventy-five percent of these events are concurrent with surface chlorophyll increase over a 5-day period suggesting that cooling events observed at the shelf break are associated with nutrient fluxes that promote the growth of phytoplankton.

RELATIONSHIP BETWEEN ZOOPLANKTON DISTRIBUTION AND HYDROGRAPHY IN DEEP WATERS OF THE SOUTHERN GULF OF MÉXICO

Färber Lorda J., Athié G., Curiel C.

Samples obtained during three different seasons (XIXIMI 1, November 2010; XIXIMI 2, July 2011; and XIXIMI 3 February-March, 2013) were utilized to study zooplankton distribution and hydrography. We observe the same distributional pattern for the three seasons. In the south, in the Gulf of Campeche, where a quasi-permanent gyre was present, we found the most productive area, with high zooplankton bio volumes. During autumn and winter, coastal currents in the same area induced by wind forcing is apparently producing an upwelling, which by Ekman pumping, is transporting, nutrients to the open ocean, increasing primary productivity. The depth of the isopycnets, showed, during the three cruises, a domed structure in the Gulf of Campeche (South of the area in front of Campeche and Veracruz states), around cyclonic and anticyclonic eddies; this in coincidence with high CDT fluorescence values and high bio volumes of zooplankton. The main zooplankton groups showed small seasonal variability, in their proportions, but a great seasonal variability in their abundances and bio volumes. For the three seasons sampled, a significant difference was found for the bio volumes. During summer 2011, after a strong rain event, great concentrations of salps were found in the Gulf of Campeche, and within the before mentioned eddies. Bio volumes during summer were 9 times higher than during autumn. Even excluding the salps volumes, during summer we did find significant differences among the bio volumes of the three cruises, with mean values 6 for autumn and two times higher for winter, than the other two seasons sampled. These results demonstrate that the Gulf of Campeche is a permanently higher productivity area, but with considerable seasonal differences.

PTEROPODS IN THE CALIFORNIA CURRENT SYSTEM: INDICATORS FOR OCEAN ACIDIFICATION ACROSS DIFFERENT UPWELLING REGIMES

Bednaršek N.

California Current Ecosystem (CCE) is one of the most vulnerable regions to ocean acidification (OA) as it is naturally experiencing low Ω_{ar} with waters reaching shelf surface during the peak of the upwelling season. Anthropogenic CO_2 impact has contributed to a 30% increase which has started to affect pteropods in their natural environment. Pteropods are a group of pelagic aragonite calcifiers that play an important role in biogeochemical cycling and food webs, particularly in highly productive upwelling regions where they are favorable food item for ecologically and economically important species. In the CCE, pteropods display increased shell dissolution, reduction in calcification and changes in their vertical distribution. These responses are closely corresponding to in situ carbonate chemistry conditions and are indicative of the declining habitat suitability. Pteropods provide an early warning signal and can be used as management indicator appropriate for low-cost assessment of the effect of ocean acidification on marine ecosystems. In addition, similarity of carbonate chemistry conditions in different upwelling regimes provides an opportunity to translate pteropod biological responses across spatial and temporal scales, making pteropods potential indicators of OA across variety of upwelling regimes.

BIOGEOCHEMICAL EXTREME EVENTS IN EASTERN BOUNDARY UPWELLING SYSTEMS

Gruber N., Byrne D. Franco A., Frischknecht M., Lovecchio E., Münnich M. & Turi G.

Extreme weather events fundamentally shape the structure of ecosystems and determine their biogeochemical functions. While this is well established for terrestrial systems, our understanding of the role of extreme events for marine systems is rather poor. This is especially true for those events associated with warming, ocean acidification, nutrient stress, and loss of oxygen. Changes in the occurrence and intensity of such biogeochemical extreme events are of particular relevance for eastern boundary upwelling systems, as they represent regions of high variability and naturally occurring low pH and oxygen concentrations, and as such are prone to an intensification of these stressors.

Here, we use hindcast simulations of fully eddy-resolving regional physical-biogeochemical models for the California, Humboldt, and Canary Current systems to determine the distribution and intensity of oceanic extreme events in the past few decades, in the present and in the near future. Our preliminary analyses show a substantial increase in the extreme ocean-acidification events in these eastern boundary upwelling systems over recent decades. This is largely driven by the long-term acidification of these systems through the uptake of anthropogenic CO₂ from the atmosphere, but recent climatic changes in these regions appear to have modified these trends considerably. In contrast, extreme ocean deoxygenation events increased only slightly. While these trends are bound to have a substantial effect on marine ecosystems and biogeochemical functioning in the upwelling systems, their overall impact remains largely unresolved. Given that the future impact of climate change will most likely primarily manifest itself through changes in extreme events, it behooves our community well to start paying close attention to this topic.

SIMULATING EFFECTS OF CHANGING UPWELLING CONDITIONS ACROSS TROPHIC LEVELS WITHIN THE NORTHERN CALIFORNIA CURRENT

Ruzicka J.J., Brink K.H., Gifford D.J., Bahr F.

A mechanistic understanding of the dynamics of complex ecosystems and their response to natural and anthropogenic stressors requires knowledge of the network of trophic relationships from primary producers to managed fisheries and consideration of the physical context in which those relationships exist. The main constraints on trophic fluxes in coastal ecosystems include the physical import of inorganic nutrients and export of planktonic production. We present an intermediate complexity end-to-end model platform that integrates physical, trophic, and nutrient cycling processes and is useful for general application to the study of coastal ecosystem dynamics. We apply this platform to the Northern California Current upwelling ecosystem. Variability in upwelling strength is commonly invoked as a driver of interannual variability in production and recruitment. However, a simple relationship between mean seasonal upwelling strength and higher trophic dynamics has not proven robust. Upwelling characteristics - phenology, duration of individual upwelling and relaxation events, and event strength - have been recognized to affect the productivity of groups throughout the food web. The model was used to simulate responses, across trophic levels, to alternate upwelling intensities and event durations. Fish productivity had a dome-shaped relationship with upwelling intensity. Productivity increased with event strength. Strong upwelling had a detrimental effect when the physical export of plankton exceeded the capacity of phytoplankton to exploit higher nutrient supply rates and the capacity of zooplankton to exploit higher phytoplankton production. If upwelling strength increases in the future (as predicted by climate scenarios), we expect a decoupling of upwelling indices and fish production as more events fall closer to the peak of the strength vs productivity curve. This model platform is useful for understanding mechanisms underlying the dynamics of coastal ecosystems and may be applied to estimate consequences of changing physical regimes and management policies to societies that rely upon them.

OCEAN ACIDIFICATION: HOW REAL IT IS FOR COASTAL ECOSYSTEMS?

Suzuki Y., Casareto B.E., Suzuki T.

Ocean acidification has emerged as one of the biggest threats to coastal organisms across the world. It is predicted that calcifying organisms as coccolithophorids, corals, molluscs and echinoderms will be seriously affected. However responses of the biota and the effects of some physiological processes as degradation and respiration may also have implications making more unpredicted results. To determine the effects of ocean acidification on the dissolution of coccolithophorids, coral rubble and diatom, we performed experiments under natural and elevated (up to 1000ppm) pCO₂. We wanted to know the role of metabolic processes (photosynthesis and respiration), organic matters and effects of associated microbial communities. When compared natural coral skeleton with white coral skeleton (control), around 80% of carbonate dissolution was due to the contribution of biological processes by the respiration of associated microbial communities. Very small amount of dissolution was due to the physico-chemical processes even under high pCO₂ condition. Dissolution of calcium carbonate occurred even aragonite saturation state (Ω_{arg}) remained higher than 1. The coccolithophorid *Pleurochrysis carterae* could adapt to high pCO₂ concentrations after some time. Growth phase and time play important role in determining the calcification and dissolution of calcium carbonate in this species. Non calcifying phytoplankton under 1000 ppm pCO₂ showed little or no change. Addition of bioavailable organic matter significantly enhanced bacterial abundance and increased net respiration. With the increase in respiration, dissolution rates also increased. Bioavailable organic matter plays an important role on calcium carbonate dissolution by increasing respiration of bacterial communities. These results showed that response (adaptation or deterioration) of coastal organisms is due to their own strength of activities and time scales within the tested pCO₂ levels. Therefore, impacts of human activities on coastal ecosystems are not so direct.

ADAPTING AS USUAL? SOCIETAL RESPONSES TO LONG-TERM CHANGE IN HIGHLY VARIABLE SYSTEMS

Allison E.H.

Societies and economic sectors associated with eastern boundary ocean currents have long dealt with the large-scale variations that characterize the biophysical dynamics of these upwelling zones and their adjacent terrestrial ecosystems. The fishing industry confronts large changes in productivity; agriculture has to deal with changes in temperature, humidity and precipitation. States deal with fluctuating economic output and communities and households cope with interannual variations in income and expenditure. Governing institutions enable diversity and mobility in livelihoods. This presentation asks whether such human systems are better adapted to deal with anthropogenic climate change than areas with more stable dynamics because they have historically had to adapt to a high degree of climate variability. Existence of diversified and geographically mobile livelihood strategies, flexible institutions and psychological preparedness for change all suggest that they are, but these adaptation strategies work only if the periodicity and amplitude of fluctuations remain within the bounds of historical experience. Climate change that produces new stable states or alters past patterns of variability could challenge strategies adaptive capacity. Research on the adaptability of human systems associated with eastern boundary currents would be a novel area for IMBER. It has the potential to contribute both to developing our theoretical understanding the societal adaptation process and to informing the adaptation planning efforts of society.

MANAGING FISHERIES IN UPWELLING ECOSYSTEMS FOR ADAPTIVE CAPACITY: INSIGHTS FROM DYNAMIC SOCIAL-ECOLOGICAL DRIVERS OF CHANGE IN MONTEREY BAY, CALIFORNIA

Aguilera S.E., Cole J., Finkbeiner E.M., Le Cornu E., Ban N.C., Carr M.H., Cinner J.E., Crowder L.B., Gelcich S., Hicks C.C., Kittinger J.N., Martone R., Malone D., Pomeroy C., Starr R.M., Seram S., Zuercher R., Broad K.

Globally, fisheries are driven by climate, governance, and market factors of social-ecological change, presenting both challenges and opportunities. The coastal pelagic species (CPS) of Monterey Bay, California, U.S.A. fluctuate widely according to the conditions of this productive upwelling system. The structure of these fisheries allows fishery participants to adapt to changing conditions to survive economic or environmental disturbances and to benefit from optimal conditions. In this region, the Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and market squid (*Loligo opalescens*) fisheries comprise a tightly linked system where shifting focus among fisheries is key to adaptive capacity and reduced social and ecological vulnerability. We identify key large-scale factors that drive focus to shift among targets and that dictate long-term landings trends, using Elinor Ostrom's Social-Ecological System (SES) framework to apply an interdisciplinary approach when identifying potential drivers of change in this upwelling ecosystem. We analyzed interactions among these fisheries since the Magnuson Stevens Fisheries Conservation and Management Act of 1976. Using a cluster analysis of landings, we identified four modes from 1974-2012 dominated by squid, sardine, anchovy, or lacked dominance, enabling us to identify external drivers attributed to a change in fishery dominance during seven transition points. Overall, we show that market and climate factors drive dominance modes transitions, with the greatest influence from El Niño events. Governance phases most dictated long-term trends in landings and are best viewed as a response to changes in perceived biomass. Considering the significant role ENSO plays in this system, 49 fishery participants were interviewed regarding how they find, trust, and communicate ENSO forecasts, and how they use information to make decisions. Our findings suggest that globally, fishery managers should consider enabling shifts in effort among fisheries and retaining existing flexibility, as adaptive capacity is a critical determinant for social-ecological resilience.

TOWARDS SATELLITE-BASED INDICATORS OF CLIMATE-DRIVEN CHANGES IN THE CALIFORNIA CURRENT UPWELLING ECOSYSTEM

Messié M., Santora J.A., Sevadjian J.C., Anderson D.M., Chavez F.P.

Coastal ecosystems are particularly vulnerable to climate change and human pressure. In particular, shifts in coastal communities are of great concern in highly productive upwelling systems as they can impact coastal fisheries and local marine populations. Therefore, it is critical that indicators of ecosystem status are developed to provide managers with the tools needed to assess trends as early as possible. Current indicators include both in situ biological measurements and satellite-derived indicators of the physical environment. The former are often delayed and sparse, while the latter do not provide a complete picture of the ecosystem response, because cascading impacts from multiple stressors acting on the marine food web are difficult to assess.

We propose an approach that considers marine populations directly and characterizes their status through a set of in situ indices matched with satellite data. Real-time indicators can be developed by finding the best proxies for ecosystem status (defined from in situ datasets) from a combination of satellite variables such as temperature, chlorophyll or else. The corresponding time series can then be assessed in relation to regional and global climate change. Developing such indicators requires comprehensive in situ datasets that simultaneously and extensively capture a wide range of ecosystem variables. Such datasets are rare, but on the U.S. West Coast long-term monitoring programs have collected biological data covering multiple trophic levels for decades. In particular, an exciting opportunity exists in central California where several ongoing funded efforts are synthesizing ecosystem information and investigating in situ ecosystem indices of biodiversity, ecosystem composition and productivity. These efforts could be leveraged to develop satellite-based indicators of ecosystem status, that could be applied to other regions where in situ ecosystem data are lacking. Here we present a preliminary set of satellite-based indicators representing the status of central California Current upwelling ecosystems.

RECENT TRENDS IN THE PERUVIAN COASTAL UPWELLING ECOSYSTEM AND CLIMATE CHANGE SCENARIOS: CHALLENGES FOR ADAPTATION

Gutiérrez D., Tam J., Romero C., Espinoza D., Quispe C., Echevin V., Chavez F.

The Peruvian Coastal Upwelling Ecosystem (PCUE) supports the largest fishing production among analog systems in the globe. Local and remote forcing drive the productivity and biogeochemical dynamics of the PCUE. Its low latitude position in the Pacific makes it especially sensitive to climate variability and climate change. This is evidenced in historic/proxy records of oceanographic variables. In particular, a significant cooling trend dominates the coastal surface waters along most of the PCUE for at least the past 30-40 years –contrasting with the offshore and the equatorial boundary waters–, which is accompanied by a positive trend in surface chlorophyll-a. Even though trend observations are compelling, the underlying physical mechanisms (e.g. involving the alongshore coastal winds) are still not clear. More recently, sea level anomaly records indicate a higher intra-annual variability, which is consistent with an increasing activity of upwelling/downwelling intraseasonal Kelvin waves. How this remotely-forced source of variability impact on the subsurface and surface physical and biogeochemical fields, which configure the habitat for the fishery resources, has not been fully established based on observations. On other hand, first regional climate change projections predict a decrease of coastal upwelling intensity and a stronger stratification of the Peruvian waters, causing a bottom-up reduction of the ecosystem productivity. Nevertheless our still insufficient understanding of the PCUE spatio-temporal dynamics and its influence on the biological life-cycles, and furthermore the current uncertainties of climate change modelling for coastal upwelling processes represent a challenge for adaptation. Certainly it will be needed a stronger precautionary approach for fisheries' management and the involvement of human dimension sciences to improve the resiliency of the natural and social systems. From the oceanographic sciences, multi-variable, high-frequency observations, phenology studies of key species, and improvement of physical-to-biological modelling applied for climate change scenarios, are some of the key tasks to achieve.

UPWELLING IN POLAR REGIONS UNDER CLIMATE CHANGE

Drinkwater K.F.

Although upwelling in the Polar Regions does not receive the attention that other upwelling regions do such as the Eastern and Western Boundary Current systems or the equatorial regions, it is important to recognize upwelling occurs in these areas with significant impacts. This is especially important since the Polar Regions are expected to undergo some of the largest changes under anthropogenic climate change. In the Arctic, sea ice has been declining rapidly. One consequence of this result is that the ice has been retreating away from many of the shelf regions. Once the ice extends seaward of the shelf break, wind-induced upwelling can occur. This in turn results in higher nutrients and increased primary production on the shelves and at the shelf break. Observations of recent upwelling onto the Arctic shelves will be presented along with possible longer term consequences. In the Antarctic, upwelling occurs around the continent associated with the Ekman response to the mean clockwise winds. The expected changes in these winds under climate change will be discussed as well as their implications on the climate, oceanography and biology of the region.

MODELLING OCEAN-LAGOON INTERACTIONS IN A SUB-TROPICAL COASTAL LAGOON AFFECTED BY UPWELLING

Aveytua-Alcázar L., Melaku-Canu D., Solidoro C., Camacho-Ibar V.F., Querin S.

Coastal regions affected by wind-driven upwelling are among the most productive areas of the world. Even if they cover only 5% of the global ocean surface, they provide about 25% of the total catch of marine fish. Given the high ecological and economic value of these systems, understanding the phenomena that govern their dynamics is of crucial importance and needs specific studies.

In the present study, we illustrate the results of the numerical modelling of the San Quintin Bay (SQB), paying special attention to the effects of the upwelling conditions on the biogeochemical dynamics. SQB is a Mediterranean-type coastal lagoon, in the Pacific coast of northern Baja California (30.45°N, 116.00°W), Mexico, covering an area of ~42 km² with an average depth of 2 m. SQB ecology is strongly influenced by the presence of *Zostera marina* and *Ulva* spp.. The Pacific oyster *Crassostrea gigas* has been cultivated commercially in the western arm of the lagoon. The main external physical and biogeochemical forcing in SQB originates from the neighbouring coastal ocean, which is influenced by upwelling. The frequency of the upwelling pulses and tidal exchanges control the temporal variability of primary production and nutrients near the mouth. To investigate these processes, we used a 2-D coupled hydrodynamic-biogeochemical model forced by tides, wind stress and heat fluxes. The biogeochemical model has been compared with experimental data of nitrate, ammonium, phosphate and phytoplankton, collected during May and August 2004, in order to tune the model parameters and to assess its ability to simulate the major biogeochemical dynamics in the lagoon. We suggest that the ability of this ecosystem to assimilate nitrate through primary production is the result of the advection of newly upwelled waters from the adjacent coastal ocean, which are brought into the lagoon through tidal advection-diffusion processes.

Poster presentation

PIGMENTS AS BIOMARKERS OF QUALITY AND ORIGIN OF ORGANIC MATTER OFF SE COAST OF ALGARVE (PORTUGAL).

Sañé E., Fatela F., Cabral M.C., Brotas V., Beltran C., Drago T.

The quality and the origin of the sedimentary organic matter has been studied off the SE Algarve coast. Surface sediments were sampled in the inner shelf of Armona, Tavira and Monte Gordo (above 60 m depth), in two occasions (spring and summer-autumn of 2014). In order to study the relationship between the quality of the organic matter and seasonality, we focused on pigments Chl-a and Chl-b. In addition, we considered chlorophyll pigments and carotenoids to assess the relationship between the origin of the organic matter and the vicinity to the estuary of the Guadiana river. Finally, we tested the relationship between the quality of the organic matter and sediment grain size. We found that the quality of the organic matter is comparable in spring and in summer-autumn. We suggest that this exceptional result can be related to the particular oceanographic conditions of 2014 that caused exceptional seasonal upwelling events, evidenced by the unusual low temperatures of the Algarve coastal water. Regarding the origin of organic matter, the influence of the Guadiana river on phytoplankton composition is evident and differentiates the sampling sites off Monte Gordo (the nearest to the Guadiana river mouth) from the two other sampling sites of Armona and of Tavira. Finally, we did not find a relationship between the quality of organic matter and sediment grain size. Generally the sediments were finer in autumn than in spring, but these differences did not influence the distribution of fresh organic matter (Chl-a and Chl-b) along the three sites. In fact the dynamics of shore sediments is different from the organic matter settlement namely the time that fresh organic material (e.g., Chl-a and Chl-b) take to settle and accumulate on surface sediment before degrading.

Poster presentation

THE US OCEAN CARBON AND BIOGEOCHEMISTRY (OCB) PROGRAM

Benway H.M.

The US Ocean Carbon and Biogeochemistry (OCB) Program (www.us-ocb.org) is a dynamic network of scientists working across disciplines to understand the ocean's role in the global carbon cycle and how marine ecosystems and biogeochemical cycles are responding to environmental change. The OCB Project Office, which is based at the Woods Hole Oceanographic Institution (WHOI), serves as a central information hub for this network, bringing different scientific disciplines together and cultivating partnerships with complementary US and international programs to address high-priority research questions. The OCB Project Office plays multiple important support roles, such as hosting and co-sponsoring workshops, short courses, working groups, and synthesis activities on emerging research issues; engaging with relevant national and international science planning initiatives; and developing education and outreach activities and products with the goal of promoting ocean carbon science to broader audiences. Current scientific focus areas of OCB include ocean observations (shipboard, autonomous, satellite, etc.); changing ocean chemistry (acidification, expanding low-oxygen conditions, etc.); ocean carbon uptake and storage; estuarine and coastal carbon cycling; biological pump and associated biological and biogeochemical processes and carbon fluxes; and marine ecosystem response to environmental and evolutionary changes, including physiological and molecular-level responses of individual organisms, as well as shifts in community structure and function. OCB is a bottom-up organization that responds to the continually evolving priorities and needs of its network and engages marine scientists at all career stages. The scientific leadership of OCB includes a scientific steering committee and subcommittees on ocean time-series, ocean acidification, and ocean fertilization. As a closely affiliated IMBER partner program, OCB provides a forum for US-based IMBER researchers. Here we will highlight recent OCB activities and products of interest to the IMBER community and discuss new opportunities for IMBER-OCB collaboration.

Poster presentation

UPWELLING FILAMENTS AND ITS ASSOCIATED FAUNA: THE MESOZOOPLANKTON COMMUNITY

Koppelman R., Martin B., Fitzek S., Cordts M., Haupt P.

In Eastern Boundary Upwelling Systems, formations of cold upwelled water develop and extend from the coast up to hundreds of kilometers offshore. These structures are called upwelling filaments and are important components for the dynamics in coastal upwelling system. They transport nutrients and plankton to the open ocean. On regional scales, the transport of water masses by upwelling filaments occasionally can be higher and more important than the Ekman transport. Such filaments are able to transport a large fraction of coastal primary production even during low upwelling intensity. However, the dimension and nature of transported organic matter depends largely on the size structure of the involved plankton community. In the course of the GENUS project (Geochemistry and Ecology of the Namibian Upwelling System), we investigated the mesozooplankton community associated to upwelling filaments. The composition and abundance of the mesozooplankton is very variable. Depending of the developmental stage of the filament, mesozooplankton abundance can be higher or lower than in the surrounding offshore waters. Several mechanisms like the exhaustion of available nutrients and the subsequent die off and sinking of the community or increased predation pressure within the filament are discussed to enlighten the fate of the transported organic material.

Poster presentation

POSSIBLE IMPACTS OF CLIMATE CHANGE ON TROPHIC CARBON FLOW AND ECOSYSTEM SERVICES IN THE SOUTHERN CHILEAN PATAGONIA

González H. E., Graeve M., Kattner G., Silva N., Castro L., Iriarte J.L., Osmań L., Daneri G., Ardelan M., Vasquez V., Cuevas A.

The southern Chilean Patagonia is an entangled area of fjords and channels which receives a high volume of freshwater from rivers and glacial discharge (terrestrial influence) and saltwater upwelled/advected from oceanic water masses (marine influence). This interplay between continental and marine influence affect the nutrient stoichiometry, organic matter input and finally affect the plankton community in an “uncertain way” that make a difficult task the modelling efforts. In this scenario, a high level of uncertainties in biological processes such trophic carbon flow and biological carbon pump, contrast with an exacerbated social-economical pressure imposed by i.e. a growing salmon-aquaculture industry.

Several oceanographic cruises and microcosm experiments have been conducted during the last decade to assess the effect of stressors such as nutrient concentration (nitrate, phosphate, silicic acid), organic matter and grazing pressure to shade light on the possible changes that would occur in the plankton community as climate change proceed (IPCC scenarios). Some preliminary results suggest the pivotal role of some nutrients (nitrate) and some functional groups such as large-size phytoplankton (mainly chain-forming diatoms) and euphausiids (*E. vallentini*) in the carbon flow through the pelagic food web and the enhancing the vertical flux of particles to deeper layers of the ocean. We also explored the effects of nutrients additions typical for aquaculture facilities on the structure and function of planktonic communities to understand the potential negative feedback on human local communities.

Acknowledgements: Financial support was received from CIMAR program (SHOA-CONA) and Ocean Certain grant EU-FP7 N°603773.

Poster presentation

CLIMATE CHANGE AND PELAGIC FISHERIES PREDICTIONS IN CHILE: CLIPESCA

Yáñez E., Silvaa C., Barbierib M.A., Sotoc L., San Martínd G., Mucke P., Parésf A., Letelierng J., Sáncheza F., Plazab F., Böhmb G., Aranisb A.

One of the priorities adopted in national and global fisheries policies is the progressive implementation of an ecosystem approach for fisheries management (EAF) to ensure the sustainability of aquatic resources. Climate Change (CC) will affect fisheries development in the EAF context and it is important to consider such effects at regional and local scales. The conceptual approach of CLIPESCA project is to link historical and future scenarios of CC with their external environmental (physical) and socio-economic (fishing effort) drivers to assess the impacts on the abundance of pelagic fish (anchovy, sardine, common sardine, jack mackerel and swordfish) species in Chile. The aim of CLIPESCA is to develop a forecast system to explore how CC will affect the future pelagic fisheries resources at the national, regional and local levels. The specific objectives: 1) update and consolidate historical (1950-2012) biological, fisheries and environmental databases; 2) study the effects of CC scenarios in the local environment using Ocean-Atmosphere Global Climate Model (OAGCM) and high-resolution Regional Ocean Modeling System (ROMS); 3) analyse relationships between historical abundance and physical environment; 4) develop multivariate ecosystem models using advanced techniques (e.g. artificial neural networks) to predict the pelagic resources from estimate scenarios of environment and fishing effort; 5) predict spatio-temporal changes in the abundance of pelagic fisheries by applying the ecosystem models and time CC scenarios developed in objective 2; and 6) develop an Internet application that allows the access to databases and predictions (www.clipesca.cl).

Poster presentation

Workshop 3: Modelling

Workshop 3: Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change		
Tuesday, 27 October		
Time	Speaker	Title
08:30 - 09:30	Welcome by IMBIZO co-conveners, and dedication of IMBIZO IV to K.K. Liu	
09:30 -10:05	Silvia Salas	Let's cooperate: the first step in marine ecosystem-based governance
10:05 -10:40	William Chueng	Impacts of global change on coastal upwelling ecosystems and fisheries
10:40 -11:00	<i>Morning Tea</i>	
11:00 -11:35	Icarus Allen	Integrated modelling of ecosystem response to climate change and anthropogenic pressures
11:35 -12:10	Barbara Paterson	Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change – a social science perspective
12:10 -12:45	Scott Ling	Marine and human systems: Addressing multiple scales and multiple stressors
12:45-14:30	<i>Lunch</i>	
14:30-15:45	Richard Hofmeister	Modular coupling of shelves and coasts
	Charlotte Weber	Modelling social science aspects of fisheries. A systematic review
	Mary Mackay	A study of small-scale fisher people's perceptions of policies, resources and the fishing industry in Sri Lanka using Q-methodology in order to identify the root causes of current industry conflicts
	Hayley Bannister	Exposing uncertainties in marine ecosystem modelling
15:45-16:15	<i>Afternoon tea</i>	
16:15-17:30	Ginevra Rosati	A combined observational modelling approach to assess the mercury budget in the Marano-Grado lagoon
	Joyita Mukherjee	Study of ecosystem health through food web model in anthropogenically affected Hooghly estuarine region, India
	Arnault Le Bris	Using integrated modelling to predict the effects of climate variability and change on the American lobster fishery
	Xavier Desmit	Reducing marine eutrophication may require a paradigmatic change
17:30-20:00	Posters and icebreaker	

Workshop 3: Modelling

<u>Wednesday, 28 October</u>		
Time	Speaker	Title
09:00-10:30	Eileen Hofmann	Projected changes and Southern Ocean foodwebs
	Eric Galbraith	The fish model intercomparison project (FishMIP)
	Laurent Bopp	On the use of climate models to project the future of evolution of marine ecosystems and ecosystem services
	Julia Blanchard	Size-spectrum models: how can they be used to support integrated analysis of marine socio-ecological systems?
10:30-11:00	<i>Morning Tea</i>	
11:00-12:30	Virginia Palastanga	Linking shelf break dynamics and primary productivity on the Patagonian Shelf: a study with idealised numerical experiments. (Poster)
	Paul Suprenand	Preparing for the inevitable: social and ecological impacts of oil spills in the Beaufort Sea, Arctic marine ecosystem. (Poster)
	Rapporteurs	Report back on the five key topics and discussion
12:30-14:00	<i>Lunch</i>	
14:00-15:30	Drafting of synthesis paper	
15:30-16:00	<i>Afternoon tea</i>	
16:00-17:30	Plenary interaction session (Debate)	
17:30-20:00	Poster Session (Drinks and snacks)	

Workshop 3: Modelling

Thursday, 29 October		
Time	Speaker	Title
08:30-09:00	Plenary report back session	
09:00-11:00	Eugene Murphy	Developing integrated models of Southern Ocean ecosystems and human interactions
	Stuart Corney	Integrated modelling for ecosystems in the Indian sector of the Southern Ocean
	Michael Drexler	Reimagining fisheries management: an agent based approach
	Kieran Hyder	Making modelling count – increasing the contribution of shelf-seas community and ecosystem models to policy development and management
10:30-11:00	<i>Morning Tea</i>	
11:00-12:30	Francisco Bravo	Spatially explicit simulation of sediment biogeochemical cycles in coastal environments, from habitat to bay scale
	Xun Zhang	Operational potential fishing zone prediction for Japanese common squid in the coastal waters of southwestern Hokkaido, Japan
	Giulia Mussap	Modelling the benthic-pelagic coupling in a coastal marine ecosystem
	Terrie Klinger	Social-ecological dynamics in the Gulf of Alaska - after the oil spill and into the future
12:30-14:00	<i>Lunch</i>	
14:00-15:30	Rapporteurs	Report back on the five key topics and discussion
15:30-16:00	<i>Afternoon tea</i>	
16:00-17:30	Plenary interaction session (Discussion)	
19:30	<i>IMBIZO Dinner</i>	
Friday, 30 October		
Time		
08:30-09:00	Plenary report back session	
09:00-10:30	Presentation of synthesis draft and further discussion	
10:30-11:00	<i>Morning Tea</i>	
11:00-13:00	Plenary wrap up	

MODULAR COUPLING FOR SHELVES AND COASTS

Lemmen C., Hofmeister H., Eisele A., Klingbeil K., Kerimoglu O., Kreuz M., Burchard H., Kösters F., Nasermoaddeli H., Wirtz K.W.

Data and models for describing coastal systems span a diversity of disciplines, communities, ecosystems, regions and techniques. Previous attempts of unifying data exchange, coupling interfaces, or metadata information have not been successful. We introduce the new Modular System for Shelves and Coasts (MOSSCO, <http://www.mossco.de>), a novel coupling framework that enables the integration of a diverse array of models and data from different disciplines relating to coastal research. In the MOSSCO concept, the integrating framework imposes very few restrictions on contributed data or models; in fact, there is no distinction made between data and models. The few requirements are: (1) principle coupleability, i.e. access to I/O and timing information in submodels, which has recently been referred to as the Basic Model Interface (BMI) (2) open source/open data access and licencing and (3) communication of metadata, such as spatiotemporal information, naming conventions, and physical units. These requirements suffice to integrate different models and data sets into the MOSSCO infrastructure and subsequently built a modular integrated modeling tool that can span a diversity of processes and domains. We demonstrate how diverse coastal system constituents were integrated into this modular framework and how we deal with the diverging development of constituent data sets and models at external institutions.

MODELING SOCIAL SCIENCE ASPECTS OF FISHERIES. A SYSTEMATIC REVIEW

Weber C.T., Borit M., Aschan M.

Today, marine fisheries are one of the great concerns of our times, with many stocks depleted or over-exploited. The science community has put considerable effort into fisheries research in order to give advice to managers and policy makers. A popular method to facilitate this knowledge transfer between researchers and policy makers is to develop a model of the fisheries system, reaching from simple mathematical models to complex simulations. This gives scientists the opportunity for a better understanding of fisheries dynamics, which might eventually lead to predictions of bio-economic and social indicators development. However, the European Commission calls for a more 'ecosystem-based approach towards fisheries', challenging the science community to include a more holistic view of the fisheries system into their models (i.e. incorporating social, biological and economic aspects alike). Additionally, governmental institutions such as the Directorate-General for Maritime Affairs and Fisheries (DG MARE) as well as intergovernmental organizations such as the International Council for the Exploration of the Sea (ICES) ask for taking cognizance of social sustainability, implying the need to recognize social sciences as a vital factor when trying to improve fisheries management. However, with a great number and high diversity of research concerning fisheries-modeling being published every year, the progress in integrated modelling methods appears difficult to assess. This makes it especially challenging to determine to what extent fisheries models have been integrating social science aspects so far. Therefore, we conducted a systematic literature review on fisheries modeling, in order to establish an overview of (1) the models available, (2) the purpose of the models (explanation, prediction etc.), (3) the diversity of modeling tools used, and, most importantly, (4) to investigate what factors and aspects of the fisheries system have been included in models so far, especially in regard to integrating social science aspects.

A STUDY OF SMALL-SCALE FISHER PEOPLE'S PERCEPTIONS OF POLICIES, RESOURCES, AND THE FISHING INDUSTRY IN SRI LANKA USING Q-METHODOLOGY IN ORDER TO IDENTIFY THE ROOT CAUSES OF CURRENT INDUSTRY CONFLICTS

Mackay M.

In order to gain a full understanding of a social ecological system, not only the trends of habitats, species and ecosystems need to be understood, but also the patterns of the users involved. Small-scale fisheries have often been a complex management issue across the world. In an attempt to overcome the unpredicted and undesired outcomes of fisheries through misaligned objectives between managers and fishers along with frequent cases of lack of compliance within the system the patterns of fishermen behaviours are vital. By understanding the perceptions and opinions it reveals drivers, which are often linked to the motivations behind behaviours. This study attempts to understand the perceptions of small-scale fisher people on policies, resources, and the fishing industry in Sri Lanka. Q-methodology is a way in which social perspectives can be revealed by analyzing the patterns in the way people associate opinions (Webler et al., 2009). Currently, in Sri Lankan small-scale fisheries conflicts are arising from different gear use and disputes of legality surrounding these gears. This will be explored through two case studies carried out in two fishing communities; Galle and Kalpitiya, as they engage and comply with the policies differently. This will result in having an understanding of the range of perspectives of fishermen, therefore making it possible to identify the different drivers for human behaviours, which contribute to the justifications for compliance in current gear policies and lack there of. With a better understanding of the complexities of compliance more informed policy recommendations could be made to contribute to more effective governance of the fisheries sector by creating a multitude of models based on the opinions found.

EXPOSING UNCERTAINTIES IN MARINE ECOSYSTEM MODELLING

Bannister H.J., Webb T., Blackwell P., Blanchard J., Hyder K.

The impacts of natural and anthropogenic pressures on the marine environment are becoming of increasing concern, resulting in an increased demand for predictions of future ecosystem conditions from mathematical models. However, the uncertainties surrounding these predictions are often ignored, a factor that could result in severe ecological and economic consequences due to misguided management advice. Identifying the uncertainties and evaluating their impact on model predictions, as well as communicating this information to decision-makers, is therefore vital to ensure the successful development of robust management solutions for the future.

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In this review we discuss the sources, level and nature of uncertainties associated with ecosystem model predictions. We then present one of the most promising methods of evaluating the impact of various uncertainties on the model output: Multi-Model Ensembles (MMEs). Finally, we discuss methods to visually communicate the extent or relative importance of each of these uncertainties to non-specialist audiences through the use of static, animated and interactive visualisations.

A COMBINED OBSERVATIONAL MODELLING APPROACH TO ASSESS THE MERCURY BUDGET IN THE MARANO-GRADO LAGOON (ADRIATIC SEA)

Melaku Canu D., Rosati G., Solidoro C., Heimbürger L.-E., Acquavita A.

We provide a first comprehensive overview of the mercury (Hg) cycle in the Marano - Grado Lagoon, by integrating mercury data and other environmental parameters with literature values of Hg kinetic processes into a model framework (WASP7-MERC) specifically developed. A biogeochemical model of the mercury cycle is applied to the Marano-Grado Lagoon (North Adriatic Sea, Italy) in order to assess the concentration of mercury species (HgII, MeHg, Hg⁰) in water, sediment and particulate, and to quantify the mercury fluxes and budget within the lagoon itself and between the lagoon, the atmosphere and the Adriatic Sea. The Marano-Grado Lagoon is a hot spot of mercury contamination in the Mediterranean Region and several monitoring activities targeting the mercury cycle have been performed here, thus making available data that has been used to build the model and to assess its skills. However, several gaps still exist in the knowledge on mercury species concentration and kinetics. Major sources of uncertainty have been considered as well. Our results highlight that the lagoon is likely to be a secondary source of contamination to the Mediterranean area and a site of net MeHg production. Because the Northern Adriatic, including the Marano - Grado Lagoon is a hot spot of Hg contamination, the information on Hg inputs to the Adriatic and to the atmosphere are crucial when assessing the Hg budget at the regional scale.

STUDY OF ECOSYSTEM HEALTH THROUGH FOOD WEB MODEL IN THE ANTHROPOGENICALLY AFFECTED HOOGHLY ESTUARINE REGION, INDIA

Mukherjee J. & Ray S.

The Sundarbans, shared between India and Bangladesh is home to one of the largest mangrove forest in the world. The mangroves of the Sundarbans act upon a variety of ecosystem services. Litter fall of mangroves supplies the detritus, nutrients and regulates the productivity of adjacent Hooghly–Brahmaputra estuarine complex and serves as an important nursery ground for many commercially important shell and fin fishes. Presently the mangrove ecosystem of Sundarbans is under serious threat for different anthropogenic activities. Major ecological problems in that area are increase in soil and water salinity, subsequent deterioration of soil fertility and productivity, pollution of soil and water ecosystem and loss of biodiversity. Anthropogenic activities have been affecting the food web and the overall system health status is gradually decaying and possibility of natural calamity is increasing. Ecological changes as well as reduction of these resources have become grounds for secondary issues like food scarcity, resulting malnutrition, increased cost of living, poverty and social disharmony among people. Collection of seasonal data of all biological components has been done. Production, biomass, respiration, import, export values for each components are quantified in terms of carbon. Static modelling approaches using ECOPATH have been applied to construct the model. The model will consider the role of biological compartments and deterioration of system health due to anthropogenic activity like overexploitation of natural resources. Biomass, yield, catch of different fish compartments are quantified and considered as basic inputs for the model. Diet proportion for each of the compartment has been quantified. Maturity of the system, organization, relative order and disorder within the system, diversity of flow of material among compartments and resilience of the system has been assessed using ECOPATH software. Different system level indices for network analysis are assessed quantitatively. Robustness of the system is also assessed using these indices.

USING INTEGRATED MODELING TO PREDICT THE EFFECTS OF CLIMATE VARIABILITY AND CHANGE ON THE AMERICAN LOBSTER FISHERY

Le Bris A., Pershing A.J., Dayton A.M., Holland D.S., Mills K.E., Sun C.

The Gulf of Maine and the northwest Atlantic shelf have experienced one of the fastest warming rates of the global ocean over the past decade, and concerns are growing about the long-term sustainability of the fishing industries in the region. The long-term trend and higher-frequency warming events have intensified the variability inherent in marine populations, fisheries and markets dynamics. The lucrative American lobster fishery occurs over a steep temperature gradient and provides a unique case study to evaluate the consequences of climate change and variability on socio-ecological systems. A long-term increase in water temperature has induced a northward shift in the productivity of the fishery, while short term events, such as an intense ocean heat wave in 2012, altered the phenology of cross-shelf migration and catchability, resulting in market saturation and a significant drop in ex-vessel prices. Using the 2012 event as a proxy for future temperature conditions, this work aims to develop an integrated climate, population dynamics, and fishery economics model to predict intermediate (seasonal and regional) and large scale (decadal and continental) consequences of climate change on the American lobster fishery. Importantly, the model aims to capture feedbacks between the lobster fishery, lobster population dynamics, and the population and fishery dynamics of the community of lobster predators. Model simulations under various management and climate scenarios will be used to identify mitigation and adaptation opportunities to improve the resilience of the fishery.

REDUCING MARINE EUTROPHICATION MAY REQUIRE A PARADIGMATIC CHANGE

Desmit X., Billen G., Thieu V., Passy P., Silvestre M., Garnier J., Dulière V., Ménesguen A., Pinto L., Gypens N., Campuzano F., Ramiro N., Lancelot C., Lacroix G.

Eutrophication is a considerable stressor of marine ecosystems at local and continental scales. In the North East Atlantic waters (NEA), most countries sustain systematic coastal eutrophication with toxic algal blooms and ecological nuisances. Marine eutrophication in the NEA directly relies on nutrient enrichment at the river outlets, which is linked to human activities and land use in the watersheds. Nitrogen emissions to Western Europe rivers are mainly stemming from agricultural practices. The sustainable governance of marine ecosystems and human societies requires to quantify these nutrient emissions and their impact at sea. The question rises of whether the human society can reduce its nutrient emissions by changing its land use without compromising its food security. To address this question, a new generic river model (PYNUTS) was designed to estimate the point and diffuse nutrient emissions (N,P) to the rivers. Nutrient emissions were computed according to land use in the watersheds across Western Europe (agro-food systems, urban structures, waste-water treatment plants). The river loads from PYNUTS have been used as inputs to three marine ecological models (MIRO&CO, ECO-MARS3D, MOHID-LIFE) covering together a large part of the NEA from the Portuguese shelf to the Southern North Sea and Celtic Sea [35°N-53°N, 13°W- 5°E]. Such a description of the land-ocean continuum allowed quantifying the impact of changes in land use across Western Europe on marine eutrophication in the NEA. A “pristine-like” scenario was tested to scale the current level of eutrophication with respect to an absolute “natural” level. Three “future” scenarios were also tested to appraise the impact of the actual EU recommendations (WFD, MSFD), and to test a more radical but still “realistic” scenario. It is shown that a paradigmatic change in agricultural practices combined with a large-scale demitarian diet might sensibly reduce both riverine and marine eutrophication levels.

PROJECTED CHANGES AND SOUTHERN OCEAN FOOD WEBS

Hofmann E.E. & Murphy E.J.

Understanding and projecting responses of marine ecosystems to changing climate conditions and direct human impacts such as fisheries requires integrated ecosystem analyses. Analyses of Southern Ocean ecosystems are no exception. Despite maintaining unique biological diversity there has been more than two centuries of exploitation of living resources, rapid changes in ocean temperature and seasonal ice cover are ongoing, and significant changes at all trophic levels are becoming apparent. Complex interactions within food webs modify responses of individual species and influence the responses of entire ecosystems to change. Reliable projections of the impacts of past and future change on Antarctic ecosystems require a fundamental understanding of the factors that determine both the structure and function of the food webs at multiple scales and approaches for incorporating this understanding into coupled modeling frameworks. Projections of changes in environmental conditions in the Ross Sea and along the west Antarctic Peninsula continental shelf over the next 50-100 years suggest significant changes in mixed layer depth, sea ice extent and wind forcing. These projected changes will be used as a basis for inferring changes in the food webs of the two regions and consequences for biological production. The latter has implications for development of management policies for marine living resources in the two regions.

THE FISH MODEL INTERCOMPARISON PROJECT (FISHMIP)

Galbraith E., Cheung W., Eddy T., Tittensor D., Lotze H.

Capture fisheries provide a major source of animal protein to humans, but their future is threatened by environmental change and overfishing. The optimization of fish harvest strategies, to ensure a reliable food supply from a healthy ecosystem, can greatly benefit from models that accurately reflect the production of wild fish as a function of environmental status and fishing pressure. However, the creation of such models is a difficult task, with many possible approaches. The Fish Model Intercomparison Project (FishMIP) aims to develop a comprehensive overview of existing models, including both detailed regional ecosystem models, and more generalized global models, in order to assess their capabilities, identify strengths and weaknesses, and chart the most critical courses for improvements. The first round of FishMIP includes a framework of standardized physical-biogeochemical scenarios, derived from general circulation models (GCMs), that include both historical reanalyses and future climate projections. Comparison of the diverse range of models, forced by the common changes in boundary conditions, will help to discriminate between robust aspects with good predictive capacity and areas of disagreement and uncertainty.

ON THE USE OF CLIMATE MODELS TO PROJECT THE FUTURE EVOLUTION OF MARINE ECOSYSTEMS AND ECOSYSTEM SERVICES

Bopp L.

In recent years, climate models have evolved towards higher spatial resolution, but also towards the inclusion of new components and processes. Many climate models used in the last IPCC assessment report now include a representation of marine biogeochemistry and of lower trophic levels in the ocean. In this presentation, I will review how these climate models can be used to project the evolution of multiple stressors of marine ecosystems (warming, acidification, deoxygenation) under contrasted future climate scenarios. I will also show how these models can be used to study the potential impact of anthropogenic climate change on upper trophic levels and associated ecosystem services. A comparison of a scenario that follows the current path of CO₂ emissions and a scenario with very low emissions demonstrates how marine ecosystems and the services they provide are sensitive to the trajectory of the climate system. I will conclude by proposing some avenues that allow more effective use of these models and results in the context of a better management of marine ecosystems in face of climate change.

SIZE-SPECTRUM MODELS: HOW CAN THEY BE USED TO SUPPORT INTEGRATED ANALYSIS OF MARINE SOCIO-ECOLOGICAL SYSTEMS?

Blanchard J.

Many different types of models are in use and are needed to assess the human impacts and dependence on ecosystems under global change. Due to their simplicity and generality size-spectrum models have been growing in application, particularly at global and macro-ecological scales. These approaches normally require much less data than species-based food web approaches and assume body size is the "master trait" dictating differences in biological rates and the trophic role among individual organisms, irrespective of their taxonomic identity. More recently, size spectrum models have encompassed greater complexity - incorporating other aspects of ecological diversity (life histories, feeding guilds, and species-specific traits) as well as linkages to biophysical and human systems. I will present a review of size-spectrum models in the context of their applications, strengths and weaknesses, gaps in knowledge and future work needed to support their use as integrated ecosystem assessment tools.

LINKING SHELF BREAK DYNAMICS AND PRIMARY PRODUCTIVITY ON THE PATAGONIAN SHELF: A STUDY WITH IDEALIZED NUMERICAL EXPERIMENTS

Palastanga V., Palma E.D., Piola A.R.

The Patagonian continental shelf (PCS) is among the most productive areas of the world ocean. Its high primary productivity sustains an intense fishing activity and is believed to drive large rates of atmospheric CO₂ absorption on seasonal time scales. Therefore, a better understanding of the physical-biogeochemical functioning of the PCS system is important to assess potential changes in the local ecosystem and ecosystem services. The goal of this study is to investigate the effect of physical processes associated to the shelf-break dynamics on the patterns of primary production and air-sea CO₂ exchange over the PCS. We present results of simulations with a regional coupled physical-biogeochemical model centered on 43°S. The model includes a northward flowing slope current in addition to winds and tidal forcing. The experiments show that slope current induced upwelling supports a maximum of new production along the shelf-break from spring to fall, whose signal is apparent in surface chlorophyll. A second chlorophyll maximum develops on the inner shelf, associated to the formation of a tidal front. The sensitivity of the results to the width and slope of the shelf bathymetry is analyzed. In general, the simulated pattern of air-sea CO₂ fluxes indicates absorption over most of the PCS, with a narrow region of CO₂ outgassing from the position of the tidal front to the coast. This spatial pattern is robust to changes in the intensity of the slope current as well as to wind variability.

Poster presentation

PREPARING FOR THE INEVITABLE: SOCIAL AND ECOLOGICAL IMPACTS OF OIL SPILLS IN THE BEAUFORT SEA, ARCTIC MARINE ECOSYSTEM

Suprenand P.M., Hoover C., Ainsworth C.H., Wetzel D.L.

Our research is focused on developing an ecological model of the Beaufort Sea Arctic marine ecosystem that considers predator-prey relationships, seasonal/environmental changes, as well as the North Slope indigenous community (Inupiat) artisanal hunting and fishing efforts. In our work we want to build the project around communicating with, and learning from, the Inupiat people and leaders in order to set cooperative research goals and to develop a practical, well-informed model. With our developed model we will simulate hypothetical inshore and offshore oil spills based on existing and potential oil extraction locations for the purpose of identifying marine species, marine habitats, and indigenous communities that are at risk of being negatively impacted by oil/oil dispersant toxicity. Negative impacts will be informed by physiological and oceanographic studies that define reductions in species' productivity, which in turn determines species' diversity, potential loss of habitat, and other long-term ecological impairments (e.g., reduced fish population and Inupiat sustenance sources over decades). In concluding our collective efforts, we aim to quantify likely cultural and ecological impacts to Alaska's North Slope marine community and ecosystem. In particular, the cultural impacts are of great interest to us, as the life of the Inupiat is intricately woven into the Arctic environment. In addition to remaining in contact with the Inupiat people throughout the project, we will communicate our findings and recommendations first with the Inupiat communities in which we have worked, and subsequently natural resource managers, scientists, as well as policy makers aimed at preserving the Beaufort Sea Arctic marine ecosystem.

Poster presentation

DEVELOPING INTEGRATED MODELS OF SOUTHERN OCEAN ECOSYSTEMS AND HUMAN INTERACTIONS

Murphy E.J., Hofmann E.E., Constable A., Thorpe S.E., Johnston N.M., Cavanagh R.D., Corney S., Melbourne-Thomas J.

Southern Ocean ecosystems support unique biodiversity, have a key role in biogeochemical cycles and maintain significant fisheries and hence contribute to global food security. These ecosystems are also undergoing rapid climate-related change and have been altered by more than two centuries of harvesting. Developing understanding of the factors that influence the structure and functioning of these ecosystems is crucial for understanding the combined effects of climate-driven and direct human impacts on species and ecosystems, for determining the responses to expected future change and for maintaining sustainable fisheries. The IMBER regional programme ICED: Integrating Climate and Ecosystem Dynamics Programme, is developing integrated analyses and models of Southern Ocean ecosystems and the impacts of change. In this presentation we briefly note the development of understanding through the ICED programme of the operation of Southern Ocean ecosystems and the impacts of change. We review recent progress towards the development of integrated ecosystem models, considering the status of models focussed on different aspects of ecosystems: biogeochemical cycles, key species dynamics, food web processes, end-to-end models of whole ecosystem operation, and projections of the impacts of future change. We also note the current objectives and model approaches used in the development of management procedures within the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR). We consider how integrated models of Southern Ocean ecosystems and management-related modelling can be developed to encompass the impacts of climate change to generate sustainable management of fisheries. We highlight the need for data-centred model development and testing to provide the evidence base to underpin decision making, and a strong focus on identifying future data needs. Although valuable, observation series alone are insufficient for the appropriate development of models, and an increased focus is required on process studies that elucidate multi-trophic interactions and human-ecosystem interactions and impacts.

INTEGRATED MODELLING FOR ECOSYSTEMS IN THE INDIAN SECTOR OF THE SOUTHERN OCEAN

Corney S.P., Melbourne-Thomas J., Constable A.J., Trebilco R., Sumner M.D., Fulton E.A.

The combination of climate change, increased fisheries and other human impacts has created a strong need for better estimates of the current, and likely potential future states of the Southern Ocean marine ecosystem. The difficulty and high cost of comprehensive observations mean that ecosystem models provide a valuable tool for understanding the mechanisms for ecosystem change, for informing the design of observing systems, and for projecting future states. Furthermore, developmental costs and the level of uncertainty in model output can be reduced by integrating existing models and by employing an ensemble of models.

In this presentation, we (the Antarctic Climate and Ecosystem Co-operative research Centre, in collaboration with the Australian Antarctic Division and CSIRO) will describe the toolbox we are developing for socio-ecological modelling and synthesis in the Southern Ocean, with a particular focus on the Indian sector, including the Kerguelen Plateau and East Antarctica. Our aim is to integrate a number of capabilities, including data analysis and synthesis, qualitative models, coupled models, and dynamic modelling of NPZD, sea ice ecology, transport of planktonic and mesopelagic taxa, individual behaviours and life histories of krill, marine mammals and birds. We are also implementing an end-to-end ecosystem model using Atlantis, coupled with a high-resolution circumpolar ROMS ocean model. We believe this integrated approach, along with an associated toolkit for model coupling and analysis, will inform improved strategies for assessment and management of marine ecosystems and help identify key uncertainties for future research.

REIMAGINING FISHERIES MANAGEMENT: AN AGENT BASED APPROACH

Scott S., Burgess M.G., Bailey R.M., Cabral R., Clemence-McCann M., Drexler M., Axtel R., Ananthanarayanan A.

Fisheries are complex coupled social-ecological systems, but ecological aspects often receive greater research attention. We present the prototype of a new mechanistic agent-based modeling platform aimed at incorporating fisher behavior in to a fuller description of the system. Behaviour is specified at the vessel level and each vessel in the model makes daily fishing decisions based on relatively simple incentives, using knowledge of its own cost structure and catch history, and the histories of catch and quota markets. The prototype is calibrated to a simplified representation of the U.S. west coast groundfish fishery.

Highly realistic macro-patterns of vessel behavior emerge under a wide range of simulated policy-combinations. For example, our vessels naturally 'fish the line' to benefit from spillover from marine protected areas (MPAs), but they avoid the line when either individual transferable quotas (ITQs) or landing taxes are used in combination with MPAs that protect bycatch hotspots. With ITQs, we find emergent lease prices to have realistic sensitivities to species' relative abundances and TACs.

As we scale up from the prototype, our platform will be coupled to a spatial ecosystem model to simulate effects below the water with greater fidelity, and market effects will be included. The final coupled model will provide a fully integrated social, ecological, and economic model capable of identifying new, simple, and robust approaches to managing human dimensions of ecosystem-based fisheries management in a changing climate.

MAKING MODELLING COUNT - INCREASING THE CONTRIBUTION OF SHELF-SEAS COMMUNITY AND ECOSYSTEM MODELS TO POLICY DEVELOPMENT AND MANAGEMENT

Hyder K.

Marine legislation is becoming more complex and marine ecosystem-based management is specified in national and regional legislative frameworks. Shelf-seas community and ecosystem models (hereafter termed ecosystem models) are central to the delivery of ecosystem-based management, but there is limited uptake and use of model products by decision makers in Europe and the UK in comparison with other countries. In this study, the challenges to the uptake and use of ecosystem models in support of marine environmental management are assessed using the UK capability as an example. The UK has a broad capability in marine ecosystem modelling, with at least 14 different models that support management, but few examples exist of ecosystem modelling that underpin policy or management decisions. To improve understanding of policy and management issues that can be addressed using ecosystem models, a workshop was convened that brought together advisors, assessors, biologists, social scientists, economists, modellers, statisticians, policy makers, and funders. Some policy requirements were identified that can be addressed without further model development including: attribution of environmental change to underlying drivers, integration of models and observations to develop more efficient monitoring programmes, assessment of indicator performance for different management goals, and the costs and benefit of legislation. Multi-model ensembles are being developed in cases where many models exist, but model structures are very diverse making a standardised approach of combining outputs a significant challenge, and there is a need for new methodologies for describing, analysing, and visualising uncertainties. A stronger link to social and economic systems is needed to increase the range of policy-related questions that can be addressed. It is also important to improve communication between policy and modelling communities so that there is a shared understanding of the strengths and limitations of ecosystem models.

SPATIALLY-EXPLICIT SIMULATION OF SEDIMENT BIOGEOCHEMICAL CYLES IN COASTAL ENVIRONMENTS, FROM HABITAT TO BAY SCALE

Bravo F. & Grant J.

Compared with more stable deep-sea environments, coastal areas are characterized by constant changes in temperature, chemistry, depositional and hydrodynamic conditions. As result, the contribution of sedimentary environments to coastal ecosystem processes vary extensively at daily to seasonal, and meter to kilometer scales.

In this context, spatially-explicit models of sediment geochemistry that consider the distribution of seascape features and forcing conditions have become a valuable tool for ecosystem-scale assessments of benthic processes, especially, when the coverage of biogeochemical measurements is limited. This approach allows considering the influence of habitat-specificity, physical forcing from the water column, and human pressures.

In this presentation we describe the current state and structure of spatially-explicit models of sediment geochemistry based on the combination of diagenetic modelling, empirical parameterization, and benthic habitat mapping. Applications include the bay-scale evaluation of C and N recycling efficiency, and the simulation of sediment – aquaculture interactions. Current results are discussed in light of its potential implications for coastal management (maintenance of ecosystem functioning), and understanding of spatial variability of sediment biogeochemical cycles.

OPERATIONAL POTENTIAL FISHING ZONE PREDICTION FOR JAPANESE COMMON SQUID IN THE COASTAL WATERS OF SOUTHWESTERN HOKKAIDO, JAPAN

Zhang X., Saitoh S.-I., Hirawake T., Nakada S., Koyamada K., Awaji T., Ishikawa Y., Igarashi H.

Total catches of Japanese common squid (*Todarodes pacificus*) by Japanese fisheries amounted to 167,500 tons in 2014 which accounted for 81% of Japan's total annual squid landings, and the coastal waters of southwestern Hokkaido are regarded as the main fishing grounds. We focused on improving fishing efficiency and facilitating fisheries management strategies. A variety of habitat models were applied to relate the fishing locations information derived from night-time visible images with daily 3-D environmental factors (u, v, w, temperature, salinity, density) in series of depth layers derived from 4D-VAR data assimilation system. Three days forward potential fishing zones (PFZ) prediction system were established and maps have been freely shared to local fishermen since 2013. PFZs were found frequently located at areas where coastal upwelling occurs in subsurface waters. Counter currents and eddies also showed close relationships with the occurrences of PFZ. Model analysis provided insights into how variability in the physical and biological properties of water environment influences temporal and spatial distributions of Japanese common squid. Predicted PFZ showed good matches with fishing locations derived from night-time visible images. Fishing activities were carried out by using our research vessel to further evaluate daily predictions and suggested the feasibility of applying our daily prediction maps into real fishing activities.

MODELLING THE BENTHIC-PELAGIC COUPLING IN A COASTAL MARINE ECOSYSTEM

Mussap G., Zavatarelli M., Pinardi N.

Integrated numerical modelling has the potential to be a strong tool for coastal planning and monitoring. It offers the possibility to test specific hypotheses and investigate the integrated effects of various factors under certain assumptions.

A coupled 1-D benthic-pelagic ecosystem model was implemented in the Gulf of Trieste (northern Adriatic Sea), an area characterized by the availability of a rich pelagic dataset and some historical benthic data. Evaluation concerned the skill of the model to reproduce the main trophic pathways, as well as their temporal variability, in dependence of seasonal variations. The ecosystem structure comprised of three phytoplankton groups, four zooplankton groups, one pelagic bacterial group, five benthonic faunal groups and two benthonic bacterial groups.

Sediment-water exchange dynamics play a critical role in coastal regions and can be regarded as an essential nutrient source for the water column. The strong interactions between pelagic primary production, benthic communities and detritus are thus crucial in defining total productivity in coastal areas.

Experiments were carried out to estimate the extent to which the model can be considered suitable for management purposes of coastal ocean. The validation indicated the successfulness of the model in replicating the observed seasonal variability of biochemical variables in the water column and of benthic distribution. However, this is only possible where the model is run against a solid hydrological background, which grants a reliable variability of the vertical density structure. Since modelling the benthic system has always been a challenge within the scientific community due to the scarcity of information available, this effort can be considered a step forward towards the development of a numerical tool to support assessment and management of marine coastal ecosystems.

SOCIAL-ECOLOGICAL DYNAMICS IN THE GULF OF ALASKA - AFTER THE OIL SPILL AND INTO THE FUTURE

Okey T.A., Klinger T., Ruzicka J.J., Himes-Cornell A.

The Gulf of Alaska (GoA) is a high-latitude system vulnerable to the combined effects of anthropogenic disturbance and climate forcing. We convened an interdisciplinary working group to study how the structure, productivity, and dynamics of social-ecological systems (SESs) of the GoA respond to environmental variability and anthropogenic stressors, and how these responses create feedbacks in SESs. We 1) assess trends in the ecosystem and identify the major drivers of change following the 1989 Exxon Valdez oil spill, 2) identify vulnerabilities within human societies to ecosystem variability, 3) and estimate ecosystem and social responses to multiple stressors, including future climate change. We integrate across SESs to identify linkages and feedbacks between the natural and socioeconomic systems. We use historical social and fisheries data, ecological data from environmental assessments, food web models, and coupled physical-biological end-to-end ecosystem models to define social-ecological feedback pathways and the consequences of natural and anthropogenic disturbances in the GoA. We compare dynamics across regional scales by employing a model of Prince William Sound (PWS) and a coupled physical-biological model of the Coastal GoA (CGoA). The PWS model with data collected since the oil spill provides a description of trophic interactions across benthic and pelagic communities occupying the more inshore ecosystem of PWS and allows comparisons of simulated and observed dynamics following a major disturbance event. The CGoA model describes the trophic interactions and nutrient cycling on the adjacent continental shelf and slope ecosystem and allows us to investigate how the dynamics of the ecosystem change under alternate current and mixing regimes. We present a subset of model simulations that integrate across socioeconomic and ecological domains, showing the effects of changing oceanographic regimes and biological community compositions on the ecological and socioeconomic health of the Gulf of Alaska in the era following the Exxon Valdez oil spill.

Workshop 4: Regime shifts

Workshop 4: From regime shifts to novel systems – evaluating the social-ecological implications of lasting ecosystem changes for resource management		
Tuesday, 27 October		
Time	Speaker	Title
08:30 - 09:30	Welcome by IMBIZO co-conveners, and dedication of IMBIZO IV to K.K. Liu	
09:30 -10:05	Silvia Salas	Let's cooperate: the first step in marine ecosystem-based governance
10:05 -10:40	William Chueng	Impacts of global change on coastal upwelling ecosystems and fisheries
10:40 -11:00	<i>Morning Tea</i>	
11:00 -11:35	Icarus Allen	Integrated modelling of ecosystem response to climate change and anthropogenic pressures
11:35 -12:10	Barbara Paterson	Integrated modelling to support assessment and management of marine social-ecological systems in the face of global change – a social science perspective
12:10 -12:45	Scott Ling	Marine and human systems: Addressing multiple scales and multiple stressors
12:45-14:30	<i>Lunch</i>	
14:30-14:45	Conveners	Introduction to the workshop
14:45-15:05	Alessandra Conversi	Regime shifts, multiple stressors, and an unbiased approach
15:05-15:25	Silvia Bianchelli	Meiofaunal biodiversity in Mediterranean ecosystem alternative states
15:25-15:45	Anne Goffart	Plankton ecosystem response to the decadal variation of winter intensity in the Mediterranean Sea: A long-term study (1979-2011)
15:45-16:15	<i>Afternoon tea</i>	
16:15-16:35	Marina Lipizer	Plankton Response in post regime shift conditions: The Gulf of Trieste, North Adriatic Sea case study
16:35-16:55	Michele Giani	Nutrients ratios trends in the Northern Adriatic sea and their potential effects on the ecosystem
16:55-17:15	Beatriz Casareto	Effect of multiple and synergistic stresses on coral reef ecosystem at micro/nano-scale
17:15-17:30	Conveners	Short wrap-up
17:30-20:00	Posters and icebreaker	

Workshop 4: Regime shifts

Wednesday, 28 October		
Time	Speaker	Title
09:00-09:10	Conveners	Short introduction to the day
09:10-09:30	Amrit Kumar Mishra	Bioavailability of trace elements in future oceanic conditions in seagrass ecosystem: ecological implications and toxicity
09:30-09:50	Prateep Nayak	Social-ecological regime shifts and the multi-directionality of drivers in coastal-marine systems
09:50-10:10	Thorsten Blenckner	Recovery versus novel ecosystems across organisational and spatio-temporal scales
10:10-10:30	Fernando Cagua	Informed recovery from undesirable ecosystem states
10:30-11:00	<i>Morning Tea</i>	
11:00-11:20	Maciej Tomczak	Ecosystem dynamics in the Central Baltic Sea during the 20th Century – what does the “desired or pristine state” really mean for us?
11:20-11:40	Christian Möllmann	A novel state in the Baltic ecosystem – Consequences for ecosystem-based management.
11:40-12:00	Martin Quaas	The Economic Consequences of Regime Shifts in Marine Ecosystems: An Application to the Baltic Sea Ecosystem.
12:00-12:20	Scott Ling	Climate change, ecological overfishing and regime shift to a highly novel alternative stable state
12:20-12:30	Conveners	Short wrap-up
12:30-14:00	<i>Lunch</i>	
14:00-14:20	Jarina Mohd Jani	Elucidating human-sea turtle interactions to ensure sustainable coastal community livelihood and marine endangered species preservation in Malaysia
14:20-14:40	Katherine Seto	Marine systems and resource conflict: Understanding fisheries conflict in West Africa
14:40-15:00	Rebecca Martone	Ecosystem changes associated with sea otter-induced regime shifts in temperate rocky reefs and consequences for human communities of NE Pacific
15:00-15:20	Julia Blanchard	Body size and the resilience of marine ecosystems to multiple drivers of change
15:20-15:30	Short summary for Plenary interaction session	
15:30-16:00	<i>Afternoon tea</i>	
16:00-17:30	Plenary interaction session (Debate)	
17:30-20:00	Poster Session (Drinks and snacks)	

Workshop 4: Regime shifts

<u>Thursday, 29 October</u>		
Time	Speaker	Title
08:30-09:00	Plenary report back session	
09:00-09:10	Conveners	Short Introduction to the day
09:10-09:30	Ingrid van Putten	A social science perspective on regime shifts
09:30-10:30	Workshop Discussion: What did we learn from the presentations?	
10:30-11:00	<i>Morning Tea</i>	
11:00-12:30	Sub-Group Discussion: Session 1	
12:30-14:00	<i>Lunch</i>	
14:00-15:00	Sub-Group Discussion: Session 2	
15:00-15:30	Workshop Discussion: Summary for Plenary interaction session	
15:30-16:00	<i>Afternoon tea</i>	
16:00-17:30	Plenary interaction session (Discussion)	
19:30	<i>IMBIZO Dinner</i>	
<u>Friday, 30 October</u>		
Time	Speaker	Title
08:30-09:00	Plenary report back session	
09:00-10:30	Final workshop discussion and preparation for the plenary report back	
10:30-11:00	<i>Morning Tea</i>	
11:00-13:00	Plenary wrap up	

Poster:

Michele Giani	Multi-decadal variations of dissolved oxygen in a Mediterranean gulf (Trieste, Northern Adriatic Sea)
Jose Iriate	Human and climatic influences on coastal waters of Patagonia: Looking for ecological indicators
Jasmin John	A more productive, but different, ocean after mitigation
Thamasak Yeemin	Assessing ecosystem services and management of degraded coral reefs after coral bleaching events

REGIME SHIFTS, MULTIPLE STRESSORS, AND AN UNBIASED APPROACH

Conversi A., Marini S., Papworth D.

While the theory of critical transitions is well developed, understanding in the field what causes ecosystems to cross a tipping point is not established. In the pelagic realm drivers of regime shifts are particularly debated. The different theories proposed however often reflect a scientific background bias, or mental model, of the investigators. An analysis of the literature suggest that ecological regime shifts are likely caused by several, interacting, time-delayed stressors, and as such a holistic approach is envisioned for their identification. In this work we test a novel approach, based on Genetic Programming - a domain-independent evolutionary computation methodology capable of generating solutions to a given problem without any strong a-priori knowledge or assumption. As a target species we have used *Calanus finmarchicus* abundance in the North Sea over the last 40 years, together with 26 physical (climate, circulation, hydrography) and trophic (predators, prey) potential drivers. The results of this analysis suggest that mainly three drivers, herring, temperature and circulation – which include both trophic (top-down) and physical (bottom up) drivers - have interacted in time towards the decline of *C. finmarchicus* in the North Sea over the past four decades. The current climate scenarios anticipate a warming $> 2^{\circ}\text{C}$ in the next decades, while at the same time additional pressures, such as fishing of top predators, will be placed on the oceans. It is therefore likely that tipping points will be reached more frequently; hence understanding the potential interactions of diverse stressors can be useful for both ecological knowledge and ecosystem management.

MEIOFAUNAL BIODIVERSITY IN MEDITERRANEAN ECOSYSTEM ALTERNATIVE STATES

Bianchelli S., Buschi E., Bonaviri C., Pinna S., Tamburello L., Pusceddu A.

In shallow rocky shores of the Mediterranean Sea, overfishing can determine outbreaks of opportunistic species, provoking regime shifts of complex ecosystems dominated by erectile macroalgae (EMA) to simpler ecosystems dominated by encrusting algae and urchins (ECA). Despite meiofauna have a prominent ecological role in most benthic ecosystems and ECA are widely distributed worldwide, information about their associated meiofauna are inexistent. We hypothesize that the shift from EMA to ECA systems exerts a strong effect on meiofauna, as observed for larger benthic components. To test this, we investigated differences in meiofaunal and nematode assemblages between EMA and ECA in six Mediterranean areas. Consistently in all the areas under scrutiny, meiofaunal abundance, biomass, and nematode biodiversity in ECA were significantly lower than in EMA. The composition of meiofaunal and nematode assemblages were significantly different between the two ecosystems at all areas, with nematode species turnover between EMA and ECA within each area higher than that among areas in each ecosystem. Our results confirm that the EMA-ECA transition can have considerable effects also on the meiofaunal and nematode assemblages, irrespectively of the area. These results highlight the need of increasing the surveillance of coasts vulnerable to this recurrent shift of shallow coastal Mediterranean ecosystems.

PLANKTON ECOSYSTEM RESPONSE TO THE DECADAL VARIATION OF WINTER INTENSITY IN THE MEDITERRANEAN SEA: A LONG-TERM STUDY (1979-2011)

Goffart A., Hecq J.-H., Collignon A.

In the Mediterranean Sea, several studies with distinct data sets indicate that the pelagic ecosystem underwent periods of change in the late 1980s and in the early 2000s. Here we used a unique long-term time series of data collected in the well-preserved Bay of Calvi (Corsica island, Ligurian Sea, NW Mediterranean) from 1979 and 2011 to explore the synchrony between changes in environmental conditions and phyto- and zooplankton dynamics. We identified an almost decadal, long-term variability in winter intensity, with three distinct periods: the 1980s (1979-1988), the 1990s (1989-1998) and the 2000s (1999-2011), which were characterized by moderate, mild and highly variable winters, respectively. We pointed out how the decadal changes in winter intensity affected (i) the duration and intensity of phyto- and zooplankton blooms, (ii) the mean yearly biomasses, and (iii) the nature of the assemblages. High phyto- and zooplankton biomasses were observed in years characterized by moderate and severe winters, and low phyto- and zooplankton abundances were recorded in years with mild winters. Moderate/severe and mild winters were favorable for diatoms and gelatinous zooplankton, respectively. Focusing on meroplanktonic species, we explored ecological consequences of decadal variations observed in the Bay of Calvi for resource management. We highlighted parallelisms with other European seas.

PLANKTON RESPONSE IN POST REGIME SHIFT CONDITIONS: THE GULF OF TRIESTE, NORTH ADRIATIC SEA CASE STUDY

Lipizer M., Cabrini M., Cataletto B., Cerino F., Del Negro P., Fonda Umani S., Fornasaro D. , Giani M., Kralj M., Monti M., Mosetti R., Solidoro C.

Plankton community composition contributes to shape the structure of the pelagic food web and the pathways of matter and energy cycling in the marine ecosystem. Temporal modifications in the composition and relative abundance of different planktonic compartments result from the synergy of multiple environmental as well as anthropogenic drivers, which in case of abrupt and substantial changes, may determine regime shifts in the state of the ecosystem which may ultimately have important implications for the upper trophic levels and for exploited living resources.

In the present study, a time-series of data (1986 – 2014) collected in a Long Term Ecological Research (LTER) coastal site of the Gulf of Trieste, North Adriatic Sea, has been reanalysed in order to explore the long-term temporal dynamics of the planktonic ecosystem and the evolution during a post-regime shift phase. During the last decades, in which the whole northern Adriatic has been experiencing cultural oligotrophication, regime shifts have been documented in the planktonic ecosystem of the Gulf of Trieste. Recent data seem to indicate the occurrence of new changes in several parameters, which suggest a reversal in the trophic trend and a recovery of the trophic conditions. In recent years, increased riverine discharges caused a higher availability of nutrients, in particular of nitrates and silicates, an increase in the abundances of some plankton compartments and changes in community composition. Here we characterize the “new” emerging system, focusing in particular on microphytoplankton and microzooplankton dynamics and relative abundances.

NUTRIENTS RATIO TRENDS IN THE NORTHERN ADRIATIC SEA AND THEIR POTENTIAL EFFECTS ON THE ECOSYSTEM

Giani M., Djakovac T., Precali R., Supić N., Marić D., Godrijan J.

Long-term changes of oceanographic characteristics of the northern Adriatic (NAd) derive from combined effects of the climate oscillations and anthropogenic impact on the biotic components. Although significant eutrophication pressure in the NAd was mainly due to increased river born nutrient load in the 1970s and 1980s, more recently, in period 2000-2010 marked oligotrophication was observed. Time series of oceanographic parameters collected in the period 1977-2014 at stations, under different eutrophic pressures of Rovinj-Po River Delta transect, were statistically analyzed. Furthermore, the variation in nutrient discharge carried by Po river was taken into account. In addition to the ongoing surface warming in the NAd, bottom temperatures revealed nearly equally significant increase, especially in winter, summer and autumn. Enhanced P limitation in the NAd occurred in warmer period of the year principally in the surface waters and in the eastern, more oligotrophic stations. The most significant positive trend was attributed to the nitrates increase in the surface layer over the entire area with a consequently increase of the N/P ratio related to higher Po river N loads coupled with decreased P loads. Particularly interesting was the trend of decreasing orthosilicate in the bottom layer in the spring and summer, suggesting a change in the phytoplankton community composition. In fact, significantly negative trend of total phytoplankton abundance were evidenced at most stations, and in addition significantly negative trend of diatoms in the bottom layer in spring on more oligotrophic eastern NAd was observed. The recently detected trends in the NAd were directly related to the increased Po River freshwater inflow in period 2009-2014 compared to the drought years (2003-2008 and to the circulation regime. The increasing N/P ratio and decreasing silicate concentrations could have marked effects on the phytoplankton and macrophytes distribution and structure in the NAd, affecting the overall trophic status.

EFFECT OF MULTIPLE AND SYNERGISTIC STRESSES ON CORAL REEF ECOSYSTEM AT MICRO/NANO SCALE

Casareto B. E., Suzuki Y., Suzuki T.

Global environmental changes are recently occurring faster than any other time. The resulting combinations of natural and anthropogenic disturbances are strongly affecting coral reef communities. Coral damage can be caused both by abiotic factors (temperature, sedimentation, nutrients inputs, ultraviolet radiation) and biotic factors (predation, overgrowth of algae, infectious diseases). These factors acting mostly in synergy had resulted in world-wide coral reef deterioration. Coral bleaching is the most impacting process that is affecting coral survival under elevated sea surface temperature and high irradiance scenario. Bleaching is well known to occur around the world; however its mechanism is not well understood. This is due to the high complexity of the “coral holobiont” (coral in symbiosis with its zooxanthellae and a microbial community that is maintain a delicate balance to keep the coral health). In this presentation a novel point of view of bleaching mechanism using micro/nano size scales will be presented: 1) the study of pigments dynamics during thermal induced bleaching revealed that bleaching is a detoxification strategy to avoid the formation of reactive oxygen species (ROS); 2) the synergistic action of thermal stress with pathogenic bacteria exacerbates the bleaching process and 3) the synergistic effect of thermal stress in a nitrate enriched environment can impede the recovery of corals after a bleaching event, turning the corals to be more susceptible to other environmental or anthropogenic stressors. This scientific approach to study effects of multiple stresses at micro/nano scales revealed the importance of organisms’ adaptations within certain thresholds.

BIOAVAILABILITY OF TRACE ELEMENTS IN FUTURE OCEANIC CONDITIONS IN SEAGRASS ECOYSTEM: ECOLOGICAL IMPLICATIONS AND TOXICITY.

Mishra A.K., Santos R., Spencer J.H.

Ocean acidification and reduced pH, affects speciation and availability of metals and metal biogeochemistry via alteration of metal uptake rates of the biota in marine ecosystem. Seagrass ecosystem production is predicted to increase in the future oceanic conditions, but in lower pH, trace elements will become more available leading to metal toxicity and act as a stressor for the seagrass ecosystem. We try to quantify the bioavailability of metals and their toxicity levels in natural CO₂ vents of Italy in seagrass *Posidonia oceanica* and *Cymodocea nodosa*. Trace elements (TE) Cd, As, Co, Hg, Cu, Pb, Fe, Ni, Mn and Zn, of sediments and seagrass (leaves, rhizomes and roots) of *Posidonia oceanica* and *Cymodocea nodosa* were analysed from the natural CO₂ vents of Italy by ICP-OES and ICP-MS technique. Trace Element Pollution Index, Trace element spatial index provided detailed concentration and availability of trace elements in sediments. Critical toxicity level (CTL) and Bio concentration factors provided TE concentration for seagrass to detect the toxicity and the difference between sediment and seagrass concentration respectively for each element. TE concentrations increased from the control towards the more acidic conditions. In acidic conditions, concentration of Fe (37625.21 mg/kg), Co (13.19 mg/kg), Pb (3.96 mg/kg) were higher in sediments, whereas Cu (248.35mg/kg), Zn (82.84mg/kg), Ni (43.00 mg/kg), As (525.30 mg/kg), Hg (0.46 mg/kg) were higher in roots, Mn (2006.59) mg/kg in rhizomes and Cd (1.74 mg/kg) in leaves. In control sites bioavailability was lower in concentration than vents. Cu (248.35mg/kg), Pb (3.96 mg/kg) and Ni (43.00 mg/kg) concentration was higher than CTL to seagrass. Bioavailability of the metals increased and varied in between sediments and seagrass significantly along the gradient with toxic effects of few TE in future ocean conditions.

SOCIAL-ECOLOGICAL REGIME SHIFTS AND THE MULTI-DIRECTIONALITY OF DRIVERS IN COASTAL-MARINE SYSTEMS

Nayak P.K. & Armitage D.

Social-ecological regime shifts are abrupt, long-term and significant changes in linked systems of people and nature with uncertain implications for ecosystem services and human wellbeing. They are difficult to predict because of an absence of early warning signals. Regime shifts may emerge slowly and imperceptibly, implying that the transition between system states may be easy to miss. We highlight the role of drivers in anticipating, navigating and averting regime shifts in coastal-marine systems. Drivers are initiators of social-ecological change and also responsible for its impacts. We illustrate here how a better understanding of multi-directional internal and external drivers, operating at multiple scales, may help to determine when and how coastal-marine systems approach thresholds and become vulnerable to abrupt change. We assess in particular the source, movement, scale, synergistic influence, and their sequence of action as fundamental attributes of drivers causing regime shifts in coastal-marine systems. These attributes offer an analytical framework to better understand where, how and when a driver can influence a social-ecological system, and with what consequences. Such detailed understanding of drivers has important implications for management of regime shifts through time and space.

RECOVERY VERSUS NOVEL ECOSYSTEMS ACROSS ORGANIZATIONAL AND SPATIOTEMPORAL SCALES

Blenckner T., Nyström M., Kininmonth S., Möllmann C.

Recovery of species populations, food webs and ecosystems following natural and anthropogenic disturbance has attracted ecologists' attention for decades. Moreover, evaluations of recovery pathways are often interpreted based on past single species baselines. In many cases baselines do not exist due to limited historical information or returning to a pristine condition is an unrealistic goal in situations with increasing pressures. From an ecosystem perspective the system may transform into a novel system. We will present a literature review on the number of studies analyzing the recovery potential of single species, trophic levels and ecosystems after the relaxation of disturbances. We will further present marine case studies to analyse the importance of species interactions and feedback mechanisms in the context of recovery potential across scales. Our results indicate that disentangling species interactions and feedback mechanisms provides opportunities to quantify species thresholds dynamics in relation to environmental pressures. The cascading effects of thresholds on one organisational level (either hierarchical in a food web context or across spatial food web dynamics) to the next level through species interactions may lead to the prevention of recovery and instead may transform into a new ecosystem state. From a management point of view, the most important challenge is to strengthen the cooperation of restoration scientists with researchers studying regime shifts and networks to create more system-orientated species goals also in the view of novel ecosystems.

INFORMED RECOVERY FROM UNDESIRABLE ECOSYSTEM STATES

Cagua E.F. & Stouffer D.B.

The complex network of interactions between species in an ecological community plays a large role in determining ecosystem responses to disturbance. In turn, disturbances like successful biotic invasions can severely disrupt ecological communities (and hence the network). At times, these disturbances can even lead to a regime shift that drives the ecosystem to an alternate stable state. As evidenced by the limited amount of success of restoration projects, bringing back ecosystems to a pre-disturbance state, or restoring them to a more 'desirable' state of ecosystem function, is a particularly challenging endeavor. On the other hand, recent work in control theory indicates that it should be possible to alter any community's composition by modifying the abundances of just a few key species. To examine its utility in a real-world scenario, we applied this framework to six pairs of invaded and uninvaded pollination networks---the network formed by interactions between flowering plants and their pollinators. In our study, we first identified the set of key species that should be prioritised in management actions to 'manipulate' ecosystem state. We then explored the feasibility of reversing the changes induced by the presence of the invasive plant, as well as whether there were key factors, such as the degree of generalisation of the invasive species, that made recovery easier in some networks compared to others. Lastly, we compared interventions that would allow the ecosystem to recover to its uninvaded state with the alternatives intended to maximise pollination rates across the community. Although our specific study focus is on plant-pollinator communities, we conclude by describing how our approach could be extended to other ecosystems, as well as its practicality for realistic community-based management.

ECOSYSTEM DYNAMICS IN THE CENTRAL BALTIC SEA DURING THE 20TH CENTURY - WHAT DOES THE “DESIRED OR PRISTINE STATE” REALLY MEANS FOR US?

Tomczak M.T., Muller-Karulis B., Eero M., MacKenzie B.R., Blenckner T., Gustafson B., Timmermann K., Norkko A., Otto S., Luzencyk A., Humborg C.

The Baltic Sea ecosystem has undergone large changes in the 20th century, related to large-scale changes in human pressures and climate variability, which have caused regime-shifts and alternative ecosystem states. Since the early decades of the 1900s the Baltic Sea has changed its state from an ecosystem with high seals population, low fishing mortality and low primary production to an overfished and eutrophicated system with low seals biomass. To reflect the long-term changes in ecosystem development, a reconstruction of hydrology and biogeochemistry by the BALTSEM model was combined with information on long-term changes in catches and species abundances. In this work we compile and analyse the available historical information in integrated trend assessment framework. Based on this information we describe Baltic ecosystem at different time-periods during the 20th century and discuss potential shift(s) and baseline and reference for ecosystem management and conservation.

A NOVEL STATE IN THE BALTIC ECOSYSTEM – CONSEQUENCES FOR ECOSYSTEM-BASED MANAGEMENT

Möllmann C., Voss R., Quaas R., Blenckner T.

Ecosystem regime shifts are ubiquitous in the marine environment and the Baltic Sea is a key example. During the late 1980s/early 1990s physical oceanographic changes and overfishing have resulted in a large-scale reorganization of ecosystem structure and function. Characteristic for the regime shift is the collapse of Eastern Baltic cod (*Gadus morhua callarias*) which forms the commercially most important fish stock of the Baltic Sea, and related cascading ecosystem changes. Hence, the regime shift had important socio-economic consequences for the Baltic Sea fisheries and the related communities. Recently, cod stock management caused a strong reduction in fishing pressure which despite earlier indications not resulted in a stock recovery. Rather unexpected consequences such as drastic growth changes were observed leading to an overall inability to assess the stock based on the traditional stock assessment procedure. Here we explore if the Baltic ecosystem has potentially developed into a new state that can be characterized based on the concept of novel ecosystems. We investigated the potential feedbacks between the physical oceanographic environment, the ecosystem and the socio-economic as well as the fisheries management system that now govern the dynamics in the Baltic Sea. We show that the environmental conditions and food web feedbacks limit the productivity of the system and hence its ability to regenerate to pre-regime shift periods, both in terms of ecosystem structure and function but as well in economic performance. We further evaluated socio-economic interactions in the system indicating that fisheries management is not sufficiently adapted towards the novel conditions in the Baltic ecosystem leading to detrimental consequences for the well-being of the local fishing communities.

THE ECONOMIC CONSEQUENCES OF REGIME SHIFTS IN MARINE ECOSYSTEMS: AN APPLICATION TO THE BALTIC SEA ECOSYSTEM

Fricke L. & Quaas M.F.

Regime shifts have been documented for marine ecosystems all across the Northern hemisphere. We investigate the role of economic feed-backs for such a regime shift in the Baltic sea in the late 1980s. Using a dynamic, stochastic ecological-economic model of the Baltic cod, herring, and sprat fisheries, we study the economic consequences of the regime shift. To this end, we analyze the distributional implications on stakeholders (fishermen, workers, consumers in the different fisheries) comparing the simulated dynamics with the regime shift with a hypothetical development without a regime shift. Considering worker and consumer surpluses arising from non-linear effects on labor and capital market, as well as imperfectly elastic demand for fish, we show that there are both winners and losers of the regime shift. On aggregate the regime shift has caused a loss for society.

CLIMATE CHANGE, ECOLOGICAL OVERFISHING AND REGIME SHIFT TO A HIGHLY NOVEL ALTERNATIVE STABLE STATE

Ling S., Sanderson C., Dominguez G., Flukes E., Marzloff M., Gardner C., Mundy C., Keane J., Baulch T., Tracey S., Johnson C.

Ecosystem change can be typified by break-point transitions whereby return to prior ecosystem states may be very difficult or perhaps impossible to achieve if the new state imposes strong feedbacks reinforcing its' own persistence. Such "catastrophic" regime shift, from productive kelp beds to impoverished 'barrens' has occurred in eastern Tasmania caused by the combination of recent climate-driven range extension of a barrens-forming sea urchin and the ecological overfishing of local sea urchin predators. In this presentation, I show how this collapsed urchin barren reef state has subsequently triggered wholesale loss of native kelp associated species, including lucrative black-lip abalone and rock lobster populations, plus concomitant 'tropicalization' of reef fishes leading to a vastly novel and stable ecosystem state. The novel trophic structure and ecological functioning of the impacted reefs has driven a shift in the human-system away from traditional fisheries practices, which target high-value native species, towards the 'post-regime shift' development of a novel fishery targeting the low-value but highly abundant range-extending sea urchin itself. While the desirable kelp bed state is ultimately recoverable if sea urchin density is reduced below the kelp recovery threshold, strong hysteresis means that, other than discrete local-scale culling of sea urchins, this system is now practically locked into a novel 'tropicalized' urchin regime. Collective findings redouble the importance of rebuilding local socio-ecological resilience to not only reduce risk of ecosystem collapse and loss of associated native biodiversity, but to also resist a wholesale shift to an undesirable, yet stable, novel ecosystem state under climate change.

ELUCIDATING THE HUMAN-SEA TURTLE INTERACTIONS TO ENSURE SUSTAINABLE COASTAL COMMUNITY LIVELIHOOD AND MARINE ENDANGERED SPECIES PRESERVATION IN MALAYSIA

Mohd Jani J., Long S.L., Jamalludin M.A., Simon A.M.

In Malaysia marine endangered species such as sea turtles face increasing threats- especially the anthropogenic type- to their sustainability despite existing legal protection. This is because policies and initiatives taken to provide their protection often fail to take into account the livelihood reality of human interactions with these species, often resulting in high level of legal disobedience with regards to the legal protective measures due to low level of social buy-in. Human pressure is an important potential contributor to the declining marine ecosystem health. Therefore, a better understanding on what sea turtles mean in the lives of those with whom they share important marine resources for various usages (habitat, food and wellbeing) is required. Moreover, human activities in natural settings and use of natural resources could also positively contribute towards ecosystem enhancement and well-being. This research aims to add a new understanding of the contingencies that riddle social behaviour that ultimately interact with sea turtle conservation through a case study in important nesting as well as foraging grounds for sea turtles in Malaysia. Recognizing the importance of these areas for local livelihood, the research uses the livelihood framework to elucidate the various dimensions of human-turtle interactions, and ethnographic and participatory field methods for data collection. With the objectives to explore both sides of human impacts, focusing on the multiple (social, economic, physical, human and natural) perspectives of the human actors on sea turtles conservation and investigate the significance of turtle conservation on the livelihood of local people; it seeks to make recommendations for effective management of the local marine resources. It therefore will contribute towards improved protection and conservation measures, thus ensuring the sustainability of both humans and sea turtles in Malaysia.

MARINE SYSTEMS AND RESOURCE CONFLICT: UNDERSTANDING FISHERIES CONFLICT IN WEST AFRICA

Seto K.S. & Easterday K.J.

Marine fisheries play a critical role in providing employment, nutrition, and income to local populations throughout the world. However, while most of these individuals are employed in small-scale artisanal fisheries, the dominant presence in global fishing law, policy, and economics is the large, often foreign owned and operated, industrial sector. The disparities and competition between these two sectors have led to growing conflict in many coastal developing countries, and a potential crisis for both the resource and the communities that rely upon it. In addition to their increasing prevalence, evidence also indicates the growing severity of many of these conflicts, which oftentimes involve destruction of artisanal boats, assault, abandonment at sea, and murder. Conflicts between small-scale fishers and industrial fleets have also been implicated in piracy and a host of human rights abuses.

A significant amount of research has investigated conflicts within small-scale fisheries, and almost as much has been dedicated to the important - if more rare - instances of interstate fisheries conflicts. However, a very limited body of literature explores the interface of these two types of fisheries, which arguably represents one of the most prevalent, violent, and growing types of resource conflict. This struggle is particularly acute in West Africa, where many states are characterized by low income, weak governance, and high nutritional reliance on fish.

Here we present research from 30 years of data in coastal Ghana, characterizing the spatial and temporal trends in fisheries conflict in this upwelling-driven system. Our research suggests that conflict is driven by biophysical, as well as social, aspects of the fishery and a social-ecological approach to governance is necessary for successful management.

ECOSYSTEM CHANGES ASSOCIATED WITH SEA OTTER-INDUCED REGIME SHIFTS IN TEMPERATE ROCKY REEFS AND CONSEQUENCES FOR HUMAN COMMUNITIES OF THE NE PACIFIC

Martone R.G., Markel R.W., Gregr E.J., Chan K.M.A.

Diverse ocean and coastal ecosystems have undergone sudden, dramatic shifts in structure and function that are often costly and hard to reverse. Changes in ocean climate, the abundance of key species, nutrients, and other factors drive these shifts, with resulting effects on food webs, habitats, and ecosystem functions that have direct and indirect impacts on people's livelihoods and well-being. But these impacts are not uniform across people, depending on their values and vulnerabilities to these changes, leading to potential conflict and negative feedbacks in the coupled human-natural system. To illustrate the variable ecological and social outcomes that can occur with regime shifts, we present a case study of temperate nearshore rocky reefs in British Columbia. The near extinction and subsequent recovery of sea otters (*Enhydra lutris*) is one of the most dramatic examples of human-induced impacts to the structure and functioning of temperate nearshore marine ecosystems. Sea otters exhibit strong top-down control of grazers, particularly sea urchins, and thus indirectly increase kelp spatial occupancy and productivity, leading to alternative kelp-dominated or invertebrate-dominated states in rocky reef ecosystems. To examine how this sea otter-mediated regime shift affects the distribution of biomass and energy across the food web and associated delivery of ecosystem services, (e.g., net primary productivity, fisheries catch, and tourism), we used a space-for-time substitution design in areas across the west coast of Vancouver Island varying in sea otter occupation time. Results from ecological dive surveys, ecosystem models, and interviews and surveys of coastal communities indicate that regime shifts do not have uniform effects across human communities and livelihoods. This work demonstrates that understanding where and for whom ecosystem changes may have positive or negative implications for social, cultural, and economic well-being is key for transparent management of coupled social-ecological systems.

BODY SIZE AND THE RESILIENCE OF MARINE ECOSYSTEMS TO MULTIPLE DRIVERS OF CHANGE

Blanchard J.

The loss of large-bodied predators vulnerable to fishing effects has impacted the structure and composition of whole food webs and assemblages. This has resulted in trophic cascades and alternate states which can hinder recovery of commercially important species. At the same time, large changes in environmental conditions, such as altered temperatures, acidities, and oxygen levels, are resulting in alterations to habitats which in turn are driving distributional shifts in species and also, potentially, reductions in body size. Although pressures are affecting the composition of traits, the traits themselves are also changing and affecting resilience to different types of top-down or bottom up pressures. Recent insights from size-based theory offer a predictive framework for testing how size-dependent traits influence community resilience. I explore whether predictions are supported by empirical observations, looking across a wide range of marine ecosystems and using a combination of empirical methods to predict early warning signals and dynamical size spectrum modelling approaches.

A SOCIAL SCIENCE PERSPECTIVE ON REGIME SHIFTS

van Putten I.

The term regime shift has a well-established meaning in ecology and the theoretical underpinnings are increasingly well understood. Understanding marine regime shifts is further facilitated by empirical information becoming increasingly available to support, change, or reject different theoretical hypotheses. The increase in empirical research is evident in the growing number of publications since the mid-1990s. Furthermore, the establishment of a regime shift database has helped in the development of this field. However not only ecological sciences (whether terrestrial or marine) use the term regime shift to describe their systems of interest. A review of the economic literature reveals that economists also use it extensively, but even though economic regime shifts are in essence a reflection of the same phenomenon, economists mainly focus on monetary analyses and related issues such as exchange rates, inflation, and interest rates. Similarly when searching sociological abstracts it emerges that this field also uses the term. In disciplines such as political science, anthropology, and sociology, regime shift is mostly associated with transformative political processes and policies. Combining understanding of regime shifts across the various disciplines has many advantages. First is a purely technical consideration of whether the dynamics of change and the potential presence of early warning indicators (such as increasing variability of key state variables) is common across the different domains. Are they really all describing similar phenomena? The second and perhaps richer avenue of understanding can be gained from looking at how connectivity across the domains may contribute or respond to regime shifts in one or other part of the broader system. Developing an understanding of the human dimension of marine regime shifts is in essence fine-tuning our understanding of the contribution of the economic and social behavioural components of socio-ecological systems (SES) and the feedback between the human and natural systems in the context of regime shift. Moreover there are two sides to the equation: i) understanding the drivers of human behaviour that lead to regime shifts and ii) understanding the consequences of regime shifts. Unpacking the disciplinary domains, direction and feedback, and driver versus consequence focus of the regime shift phenomenon is useful. The combined frameworks could prove useful if the aim is to recognise certain behaviours that might be indicative of, or increase the risk of, potential regime shifts in the future. The latter is of interest to learn how to anticipate change that may occur, anticipate change that is about to occur, how to best deal with changes after they have occurred, and also how to increase robustness and resilience for the future. It is timely to review the literature on how the human dimensions of marine regime shifts have been discussed and how the different system interactions and typologies have been presented. Potential extension to the current knowledge base are discussed and future areas of research proposed.

MULTI-DECADAL VARIATIONS OF DISSOLVED OXYGEN IN A MEDITERRANEAN GULF (TRIESTE, NORTHERN ADRIATIC SEA)

Giani M., Celio M., Kralj M., Lipizer M., De Vittor C., Čermelj B., Mozetič P.

The Gulf of Trieste is a shallow basin, located at the northernmost latitude of the Mediterranean Sea and it is subject to riverine inputs and strong seasonal variations in temperature and salinity. The river-borne nutrient discharges coupled with the circulation regime, which occasionally determines a closed circulation and the entrainment of waters in the northernmost part of the sub-basin, have caused episodic late summer – early autumn hypoxic and anoxic events during the 1970s, 1980s and beginning of the 1990s, which provoked the mortality of benthic fauna. In recent decades, however, an oligotrophication trend has been attributed to a marked decrease in the continental discharge of nutrients and in particular of phosphates. In order to verify if this trend has induced changes in the occurrence of hypoxic events and if warming, observed in the Gulf of Trieste mainly in the subsurface layers of spring and early summer, has modified seasonal stratification, we have analyzed some of the existing multidecadal time series of temperature, salinity, nutrients, dissolved oxygen concentrations and of chlorophyll a, considered as a proxy of phytoplankton biomass. Preliminary results of the analysis of data collected in three time-series stations of the Gulf, from 1983/86 to 2007/2013, mostly on a regular monthly basis, show a tendency toward increasing oxygen concentrations in the bottom waters and no deoxygenation trend in the surface waters. Remarkable variations of nutrient loads discharged by local rivers occurred during the last years, from the extreme drought in the mid 2000 to increased floods in the 2010s, which induced consequent variations of phytoplankton biomass and in the oxygenation of the water column.

Poster presentation

HUMAN AND CLIMATIC INFLUENCES ON COASTAL WATERS OF PATAGONIA: LOOKING FOR ECOLOGICAL INDICATORS

Iriarte J.L., Ardelan M., González H., Nahuelhual L.

Patagonia region depends upon its coastal resources for economic and societal well-being, with around 80% of people settled near-shore and the coastal economy accounted for more than 40.000 jobs. However, this natural and pristine system is experiencing simultaneously human and climatic types of perturbations. In this new scenario, climatic (natural) and non-climatic (anthropogenic) stressor are the major drivers of change of the structure and functions of the food webs and the “biological carbon pump”, mainly through a) changes in freshwater inputs, and b) changes in flux of inorganic nutrients in the photic zone (which will may lead to eutrophication due to aquaculture activities), both of them affecting the ocean pH and total alkalinity and pCO₂ variables. Thus, there is great uncertainty about how those changes will affect basic functionalities and feedbacks responses of coastal systems and the coupling with hydrological processes (river streamflow). Our hypothesis pointed out that under actual conditions of reduced freshwater input, to northern Patagonian fjords as a consequence of climate change, in combination with nutrient addition from aquaculture activities, may consequently affect the carbonate system in surface waters and therefore unbalanced primary productivity (decrease) and community respiration (increase) processes. We presented preliminary results of chemicals and biological variables that are systemic-sensitive, may be useful for managers, and could be designed to prevent ecological and socio-economic impacts from increasing natural (i.e. volcanic eruptions, low streamflows) and anthropogenic (i.e. aquaculture) phenomena in the Chilean southern coastal system.

Poster presentation

A MORE PRODUCTIVE, BUT DIFFERENT, OCEAN AFTER MITIGATION

John J.G., Stock C.A., Dunne J.P.

Ocean warming under greenhouse gas (GHG) accumulation has been projected to enhance ocean stratification, exacerbate nutrient limitation of phytoplankton, and decrease marine net primary production (NPP) over the next century. Studies of the reversibility of warming further suggest a lagged recovery of global mean sea surface temperatures after GHG mitigation, raising the question of whether NPP may also be slow to rebound. In this study, we consider the question of NPP reversibility with a mitigation scenario in which projected Representative Concentration Pathway (RCP8.5) forcings are applied out to 2100, and then reversed over the course of the following century in a fully coupled carbon-climate earth system model. In contrast to the temperature lag, we find a rapid increase in global mean NPP, including an overshoot to values above contemporary means. The NPP overshoot is driven by a similar overshoot in the maximum monthly mixed layer depth arising from a transient imbalance between the cooling surface ocean and waters at intermediate depths (~100-400m) that carry strong legacy effects of warming in the 21st century. Residual warmth in these subsurface waters weakens upper ocean density gradients, resulting in deeper mixing and enhanced surface nutrients despite the continued presence of significant legacy warming and freshening in surface waters. Enhanced surface nutrients combine with the positive effects of residual warming on phytoplankton growth and nutrient recycling to drive the global mean NPP overshoot. Regional variations in NPP reversibility are strong however, with some regions experiencing prolonged suppression of NPP. We also find a marine ecosystem regime shift as depletion of silica at intermediate depths over the 21st century warming and mitigation period results in increased prevalence of large, non-diatom phytoplankton.

Poster presentation

ASSESSING ECOSYSTEM SERVICES AND MANAGEMENT OF DEGRADED CORAL REEFS AFTER CORAL BLEACHING EVENTS

Yeemin T., Sutthacheep M., Suebpala W., Pengsakun P., Klinthong W., Sangmanee K., Samsuvan W., Putthayakool J., Thummasan M.

Coral reef ecosystems provide a lot of economic benefits, such as reef tourism, recreational fisheries, fisheries production, shoreline protection and natural products. However, coral reef ecosystem services are threatened by various anthropogenic and natural disturbances, especially mass coral mortality derived from coral bleaching events. Determining how ecosystem services are associated with biodiversity is required for investigating the consequences of biodiversity loss and for setting objectives and priorities for coral conservation and management. Studies on functional redundancy within coral communities, the number of taxonomically distinct species that show similar ecological functions, are very important for understanding the consequences of biodiversity loss. This study investigates a number of case studies for assessing coral reef ecosystem services in the Gulf of Thailand and the Andaman Sea with emphasis on linking coral reef conditions with various types of ecosystem services. The coral reefs in Thai waters are categorized into four different groups depending on their threats and type of uses. The coral reef that is in a degraded status and is used for tourism is the priority area for coral reef rehabilitation. The coral reef restoration plan concentrates on using passive restoration in four strategies and fifteen measures, by reducing threats from tourism, water pollution, sedimentation and fisheries. The active coral restoration by numerous asexual and sexual reproduction methods and techniques must be carefully considered prior to applying at appropriate reef sites. The major concerns are simple and cheap restoration methods, community involvement, high tolerant species to bleaching and multi-species transplantation. The future research should cover the aspects on primary productivity in coral reef system, biogeochemical processes related to nutrient cycling, and using coastal ecosystems as carbon stocks known as “Blue Carbon”. Managing coral reefs in the face of climate change is crucial for maintaining their ecosystem services and benefits to coastal communities.

Poster presentation

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