

Appendix 7
SCOR/Future Earth Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)
Project



**Integrated Marine Biogeochemistry and
Ecosystem Research (IMBER)
Annual Report to SCOR, July 2014**

A. Introduction

The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project (www.imber.info) is an international global environmental change research project, co-sponsored by the International Geosphere-Biosphere Programme (IGBP) and the Scientific Committee on Oceanic Research (SCOR). IMBER science is directed at addressing the goal of developing a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth System and human society. The IMBER Science Plan and Implementation Strategy (SPIS) published in 2005 outlined science questions and approaches for addressing this goal. The SPIS was updated in 2010 when the Global Ocean Ecosystems Dynamics (GLOBEC) project ended and some of its activities were incorporated into IMBER. Thus, IMBER is now approaching its ten-year mark, and it is appropriate to assess project accomplishments, reconsider the project goal and science questions, and to develop an agenda that will form the basis for the next 10 years of IMBER research.

To assist in the process of project evaluation and future planning, IMBER convened an Open Science Conference (OSC) titled, '*Future Oceans – Research for marine sustainability: multiple stressors, drivers, challenges and solutions*', in June 2014 in Bergen, Norway. The goals of the OSC were to provide the opportunity for the larger marine science community to present key findings from IMBER-relevant research, to promote integrated syntheses of IMBER research, and to develop a science plan for future IMBER research. Prior to the OSC during spring 2014, a draft position paper was prepared using inputs gathered from IMBER regional programmes, working groups, and partner organizations. From these inputs, five research themes emerged:

- Continued integration of marine biogeochemistry and ecosystem research
- Impacts of global change and climate variability on marine systems
- Role of multiple drivers and stressors, and responses of society
- Integration of marine biodiversity and conservation
- Integration of ocean-human systems

Also data management and capacity building were highlighted as important mechanisms for facilitating and implementing the research challenges and questions included in the five themes.

The draft position paper was provided to participants prior to the OSC and presented in a plenary presentation. Each of the themes, data management, and capacity building were discussed in breakout groups during the OSC and the inputs from each were reported in a plenary session. In parallel, an online survey was implemented to allow for additional inputs from OSC participants and the community. The position paper is now being revised based on these inputs and subsequent discussions with the IMBER Scientific Steering Committee. The primary change is that the five themes will be incorporated into a small number of overarching grand challenges that provide direction for IMBER research beyond 2015. The intent is to have a draft of the revised paper available for community comments by mid- to late August 2014. A summary of the position paper will be provided to SCOR for discussion at the annual meeting in September 2014 with follow-on interactions with IMBER. The final version of the paper should be available by the end of 2014 and this will provide the basis a 10-year extension request to SCOR.

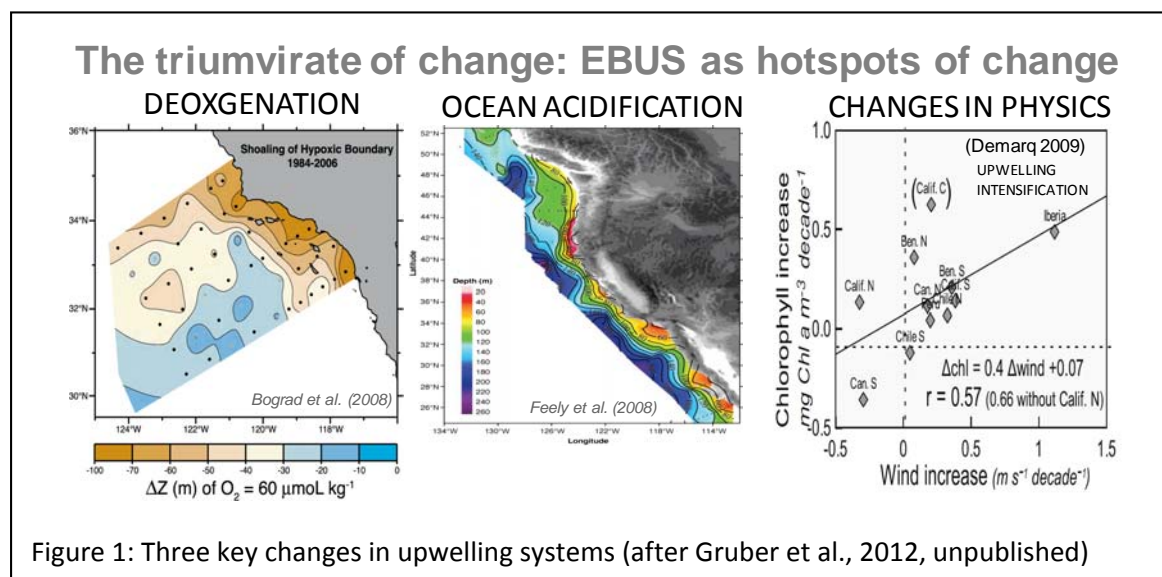
IMBER has a strong commitment to basic curiosity-driven science and this is the foundation on which an agenda for the next 10 years of research will be based. However, the environmental issues facing society, particularly those

relating to global environmental change, are at the interface between natural and social sciences and humanities, where the understanding provided by curiosity-driven, natural science merges with problem-driven, societally relevant and mostly integrated research. This is underscored by the science highlights presented in the next section, which are drawn from the plenary presentations given at the IMBER OSC. Each of these presentations focused on scientific achievements, but also provided a view to the future. For all, the research challenges that were highlighted involved some degree of coupling between natural, human, policy and governance systems related to the marine realm.

A clear message to IMBER from OSC plenary and contributed presentations, the inputs to the position paper, and feedbacks received from the OSC participants is that research that includes these interfaces must be part of any future science agenda. While the research landscape and its organisation are evolving at the global level, the IMBER community is well poised to take the lead in developing this area of marine research. Exciting changes and challenges are facing our community and dealing with these in a proactive, forward-thinking manner is key, both for now and the future.

B. IMBER science highlights from the Open Science Conference, 2014

The IMBER OSC was attended by about 485 participants, who represented 48 countries, including 16 developing countries. The final programme included 5 plenary sessions, 11 workshops and 21 contributed sessions, representing all IMBER science themes, regional programmes, working groups, and related communities. The science highlights presented in this section, which are drawn from the OSC plenary presentations, provide an overview of IMBER science achievements, highlight the rationale for the five themes in the draft position paper, and introduce new ideas for future IMBER research.



Plenary Talk, Nicolas Gruber: This presentation, “*Warming up, turning sour, losing breath – the regional perspective*”, focused on the consequences of pH changes, ocean acidification, and de-oxygenation using specific examples from the California Current, an eastern boundary current upwelling system (Fig. 1). Recent advances in observational capability have captured changes in the physical, biological and chemical characteristics of the California Current resulting from ocean acidification and low oxygen.

Advances in modelling capability and incorporation of new observations into models have allowed projections of these trends into the future, identification of important controlling processes, and attribution of uncertainty to the future projections. The latter effort has highlighted the importance of extreme and rare events in driving change in marine systems (Fig. 2). The combined modelling and observational efforts allow identification of marine ecosystems that are most vulnerable to the effects of changing pH and reduced oxygen and provide guidance about controlling processes.

Plenary Talk, Kon-Keo Liu: Research accomplishments and future research needs for continental margins were presented in, “*Anthropogenic impacts on biogeochemical processes and ecosystems in continental*

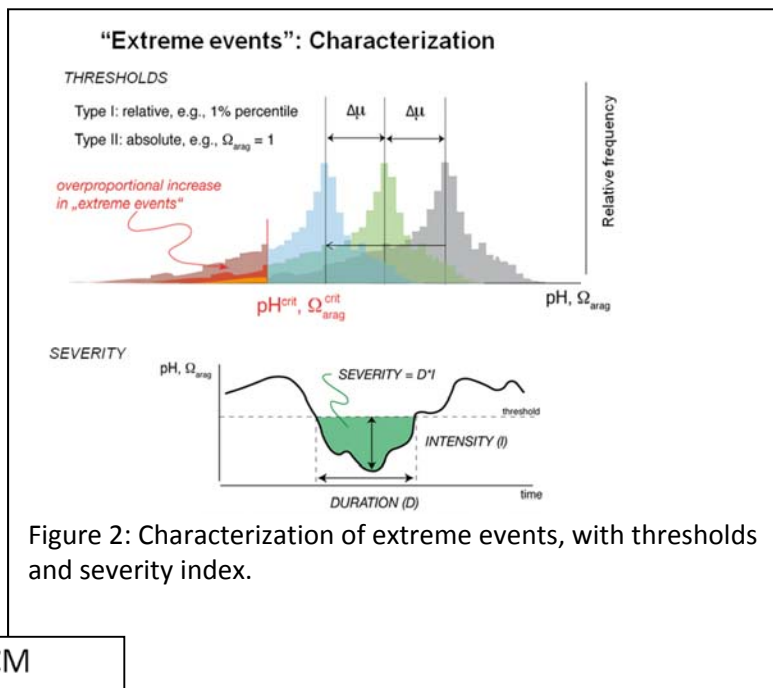


Figure 2: Characterization of extreme events, with thresholds and severity index.

Knowledge and understanding in CM

- From watershed to coastal ocean processes
- From ecosystem functioning to societal values
- From exploitable resources to governance arrangements

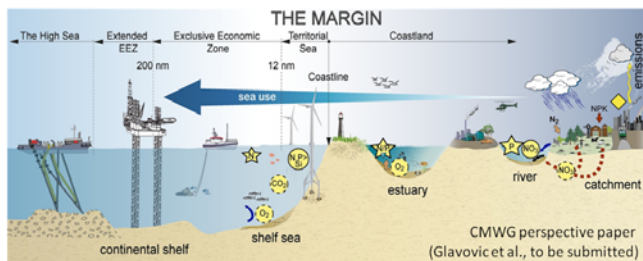


Figure 3: A representation of the continental margin, after Glavovic et al., in preparation.

margins – lessons learned from cases around the globe and future perspectives”. This presentation focused on the growing importance of continental margins for providing resources and services for human, marine and maritime activities. At the same time these systems are vulnerable, and climate-related changes are moving continental margins towards possible tipping points. New research strategies that foster sustainable use of continental margins are being developed that include from the outset consideration of innovation, risk and governance (Fig. 3).

Plenary Talk, Coleen Moloney: From its beginning, IMBER has had a focus on integrating marine biogeochemical cycling and food web dynamics. The presentation, “*Food webs and biogeochemistry in a changing marine environment*”, provided a synthesis of IMBER accomplishments in developing end-to-end views of marine ecosystems (Fig. 4). This approach is key to developing and exploring (e.g., climate and fishing) scenarios of future changes in the marine environment, understanding its resource and service provision, and to furthering predicting capacity at local and intermediate complexity/integration levels (Fig. 5).

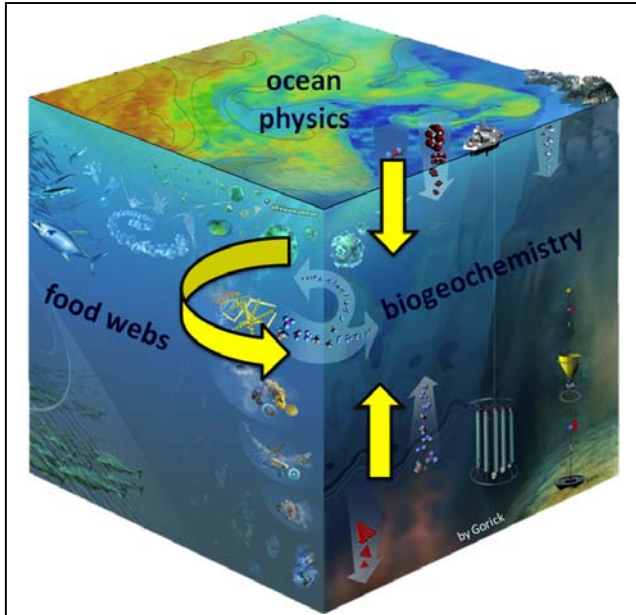


Figure 4: Gorick image with key oceanic processes

This presentation highlighted potential impacts of ocean acidification, but took the longer view that these impacts are acting in combination with other drivers and stressors (Fig. 6). The potential role of ocean acidification at local, regional and global levels is significant, but understanding of related physical-chemical, physiological, ecological, societal processes associated or depending on ocean acidification is still limited, especially when multiple drivers and stressors are considered (Fig. 7). This is an area for future research and the IMBER community is well positioned to take the lead.

New process understanding, such as mixotrophy and parasitism, remain to be incorporated into trophic process models. However, the progress that has been made is substantial and for some marine ecosystems, scenario testing and projections are a reality. Models of intermediate complexity for ecosystem assessments (Fig. 5), which extract information from a suite of models developed for different aspects of an ecosystem, were highlighted as the approach for scenario testing and projecting future states of marine ecosystems.

Plenary Talk, Jean-Pierre Gattuso: Advances in an area of marine research that has been a priority focus for IMBER (and SOLAS) were summarized in, *“Drivers of and responses to ocean acidification”*.

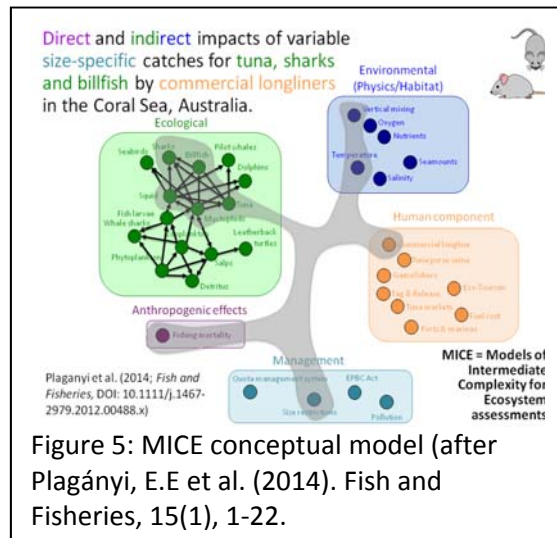


Figure 5: MICE conceptual model (after Plagányi, E.E et al. (2014). Fish and Fisheries, 15(1), 1-22.

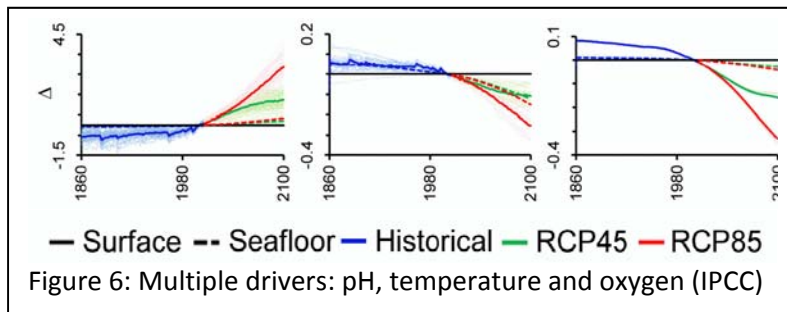


Figure 6: Multiple drivers: pH, temperature and oxygen (IPCC)

Plenary Talk, Claudio Campagna: The potential biodiversity crisis that the marine environment is facing in the coming decades was presented in, “*Marine Conservation in the time of Global Change*”. This potential crisis is associated with the values issues of human society in terms of how marine resources are viewed. Efforts are underway to explore the threats and trends for iconic species’ biodiversity.

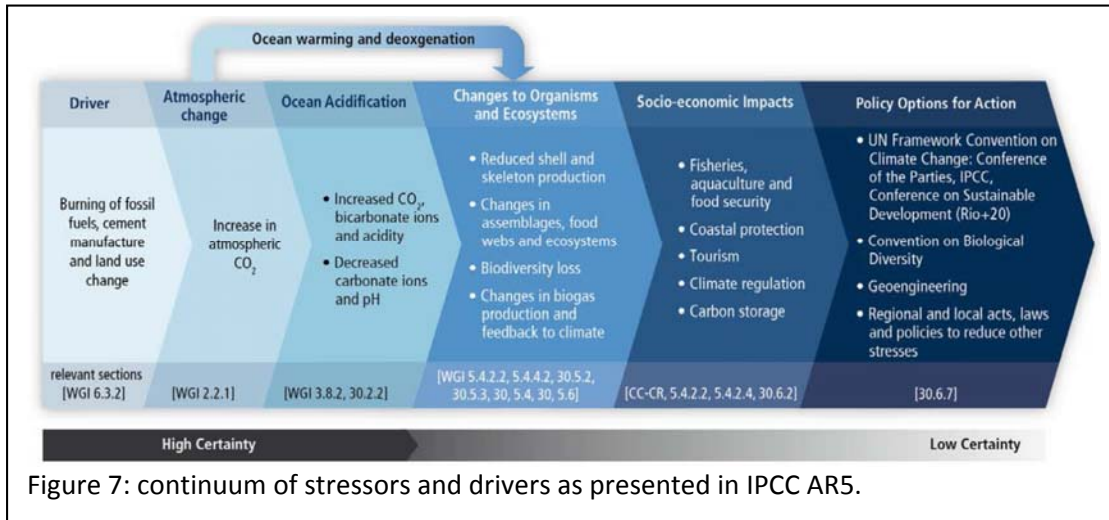
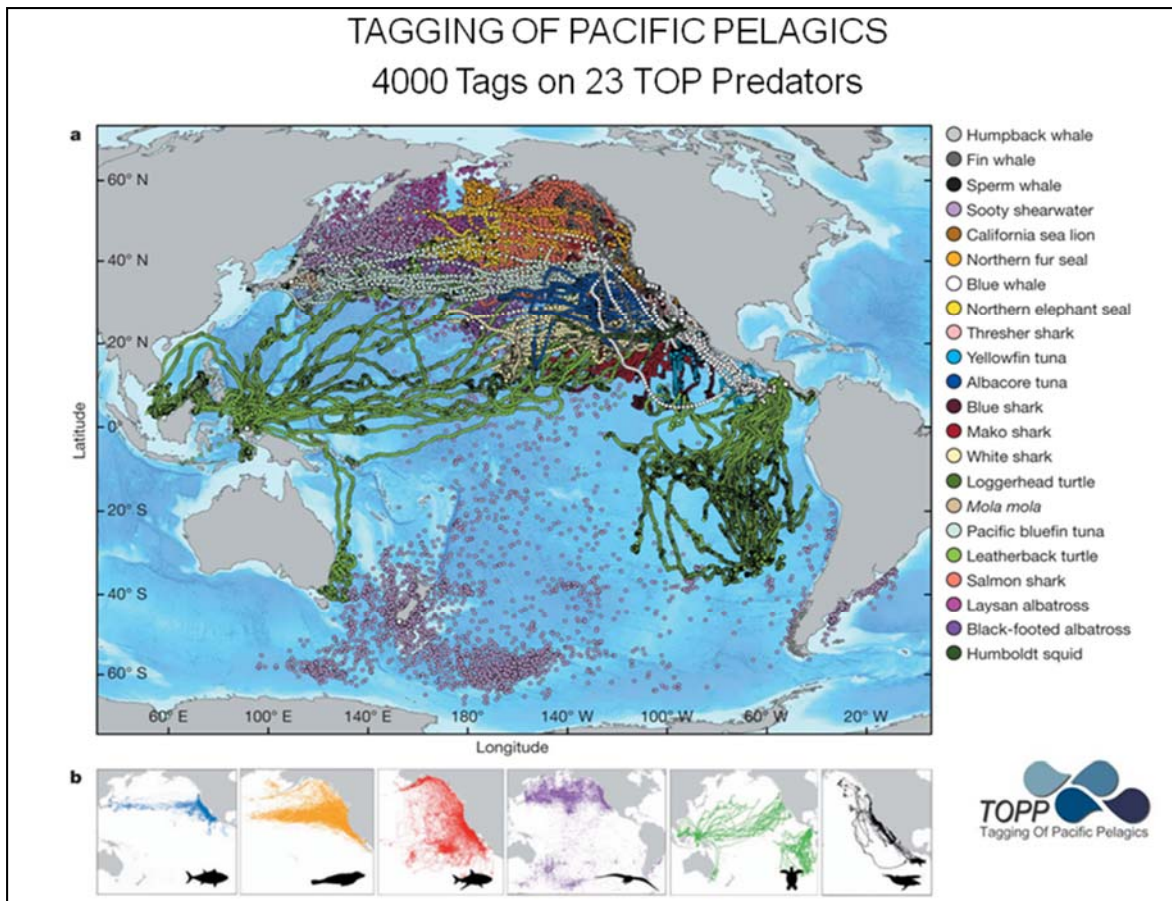


Figure 7: continuum of stressors and drivers as presented in IPCC AR5.

Among useful new methods and approaches are tagging and remotely sensed monitoring of individuals, which provides information on behaviours, habitat use, and species range (Fig. 8). The establishment of Marine Protected Areas provides one possible approach for conservation for marine biodiversity, but more evaluation and research are needed to determine the effectiveness of these regions. Limited progress has been made in terms of conserving



biodiversity in the marine environment, and much remains to be done. Marine biodiversity and conservation is an important area for future IMBER research and it is a natural extension of the research that is ongoing in the regional programmes.

Plenary Talk, Alistair Hobday: The contributions that IMBER research has made to the understanding of responses of top predators to global change were summarized in the presentation, “*Climate change impacts and adaptation options for high trophic level marine species*”.

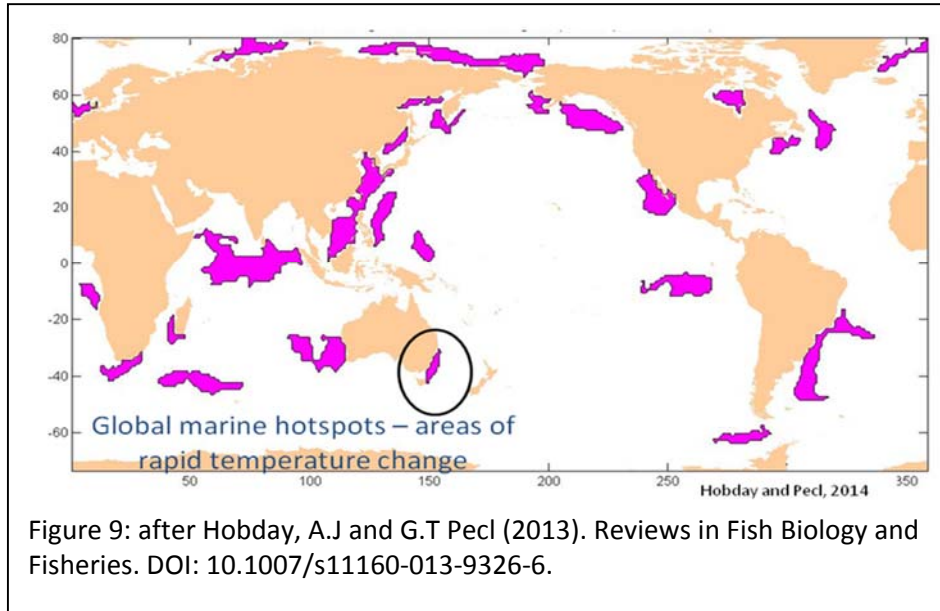


Figure 9: after Hobday, A.J and G.T Pecl (2013). Reviews in Fish Biology and Fisheries. DOI: 10.1007/s11160-013-9326-6.

New integrated approaches, methodologies used at the individual or species’ levels, and new data (e.g., inter-oceanic comparison of top predator diets and ecosystem trophic structure) have improved prediction capability for various scenarios of climate change, such as changes in habitat suitability for commercial species (Fig. 9) and allowed linkages to be made between areas of rapid temperature

change to threats to key marine species and fisheries (Fig. 10).

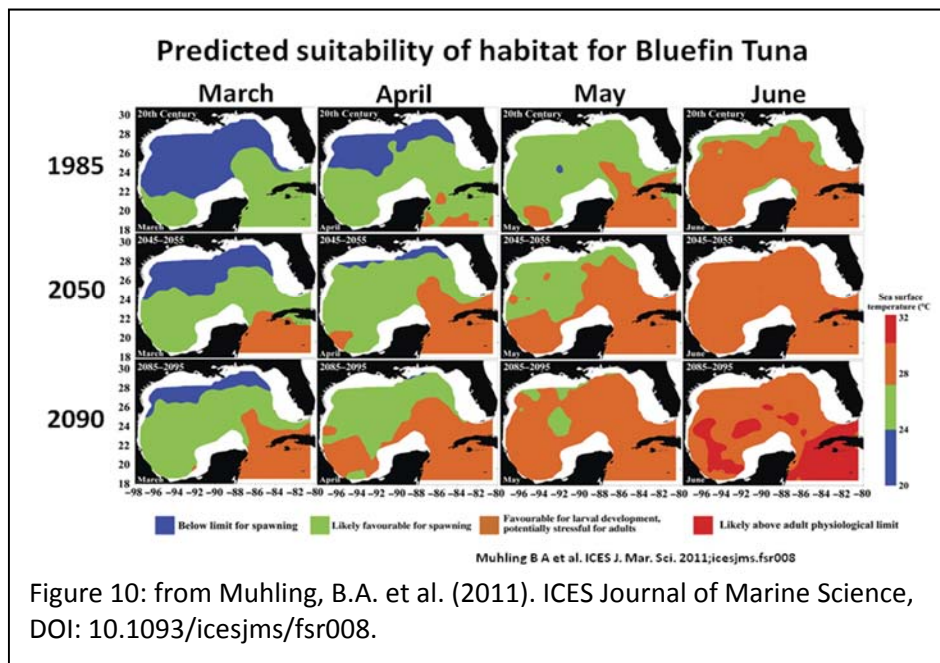


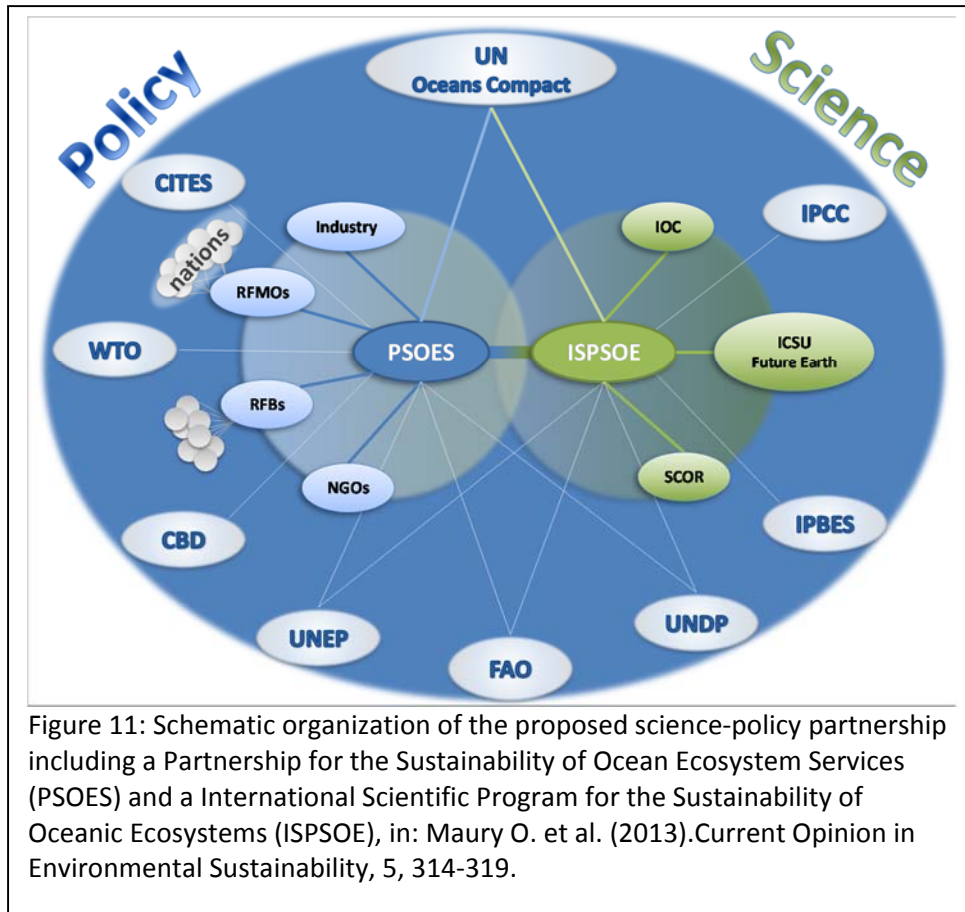
Figure 10: from Muhling, B.A. et al. (2011). ICES Journal of Marine Science, DOI: 10.1093/icesjms/fsr008.

A new conceptual vulnerability research framework was proposed that explores adaptation options, applicable either locally or at the species level. The adaptation process is iterative, and closely links ecological and societal systems and their respective vulnerability. Changes are underway in many marine systems and change is predicted to continue. Continued documentation of these changes (e.g., fisheries decline) is important to developing the understanding and strategies needed to change the trajectory of

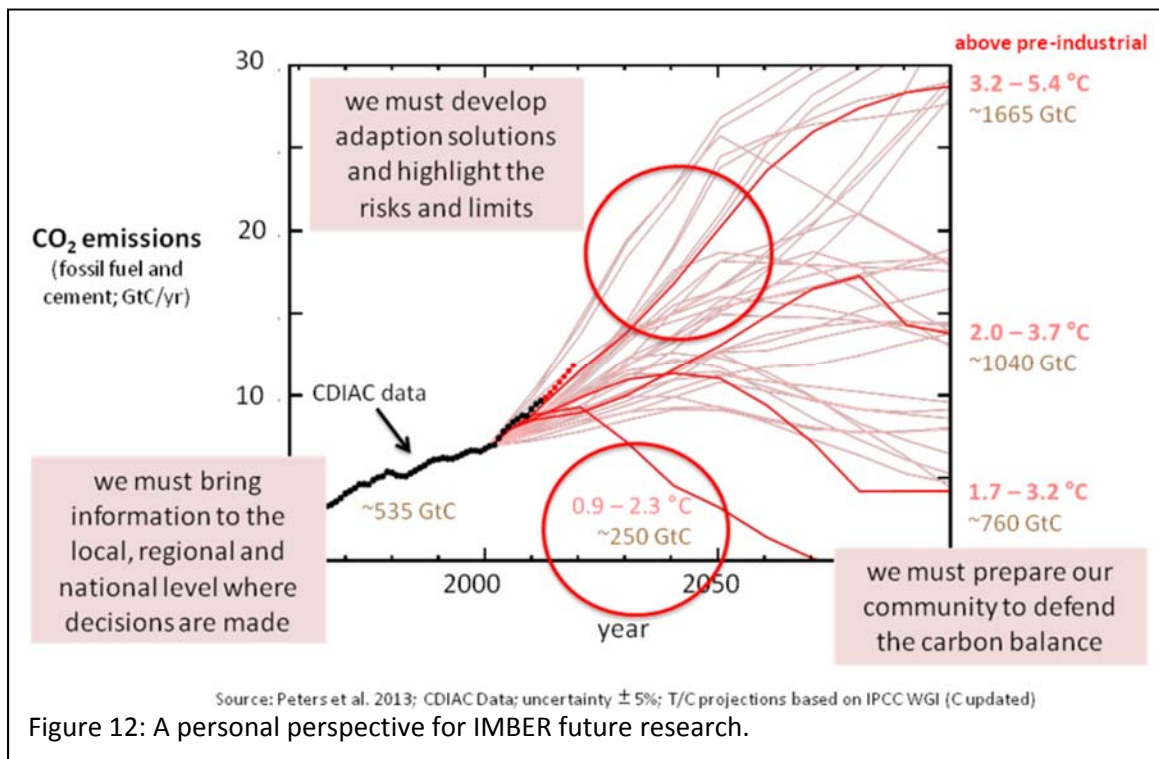
the change and to help species, people, and institutional systems to adapt to the change. Options exist to respond to climate change effects on pelagic top predators, but adaptation will be difficult for open ocean species, and will require the involvement of managers, policy makers, and institutions from the outset.

Plenary Talk, Alida Bundy: “*Dead ends and grasping hands: failed governance and the need to integrate human-ocean interactions into global change science*” focused on research needs for improving understanding of

human-ocean interactions, with specific examples drawn from marine fisheries. A social-ecological systems approach and a truly integrated dialogue across the natural and social science disciplines and among multiple stakeholders are needed, which requires a new integrated, co-designed research agenda (Fig. 11). Development of science-policy partnerships, through the institutions involved in the assessment and management of marine resources



and services, *and* also at the level of the individual research, is a start to this process. The IMBER-ADApT decision support tool was developed by the IMBER Human Dimensions Working Group. This tool will enable decision makers, researchers, managers and local stakeholders to improve responses, make decisions efficiently to transition towards marine sustainability, and evaluate where to most effectively allocate resources to reduce vulnerability and enhance resilience of communities to marine global change. This approach will advance and improve the impact of current research endeavours underway in the IMBER regional programs.



Plenary Talk, Corinne Le Quéré: Inputs from the Future Earth Scientific Committee, that also built upon recent progress by the IPCC from inputs by the marine research community, were provided in, “*From CO₂ surveys, nutrient budgets, ecosystem process studies and modelling, to the Future Earth era: preserving our strengths and shaping new opportunities for the IMBER community*”. The approaches used by IMBER and the IPCC are complementary to developing scenarios, projections and predictions, that help decision-making processes (as based on scientific evidence for environmental policy) and help promote sustainable societal transitions. The strengths of the IMBER community and the possible pathways for a strong IMBER-related contribution in Future Earth (Fig. 12) were highlighted.

C. IMBER Regional Programmes

Ecosystem Studies of Sub-Arctic Seas (ESSAS) Regional Programme

The ESSAS programme (www.imr.no/essas) focuses on the impacts of climate change on sub-Arctic marine ecosystems and their sustainability. In April 2014, ESSAS held its Annual Science Meeting (ASM) in Copenhagen, Denmark. The focus for this meeting was the paleo-ecology of the Subarctic Seas, biology and ecology of Arctic cod species, human responses to major shifts in fisheries, comparative and modelling studies, and the biological impacts of the Atlantic Multidecadal Oscillation. The ESSAS SSC met following the ASM to review recent ESSAS activities and to develop a future research plan. Following a request from ESSAS, Greenland appointed a new member, AnneDorte Burmeister, a crab biologist, as a replacement on the ESSAS SSC for Kai Weiland, who no longer is working in Greenland waters. The ESSAS co-chairs convened a session on, “*Changing ecosystems in sub-Arctic and Arctic regions*”, at the **IMBER OSC** in June 2014, Bergen, Norway.

ESSAS Working Groups

The *WG on Modelling Ecosystem Response* is involved in a special volume on *Modeling and observational approaches to understanding marine ecosystem dynamics* in *Progress in Oceanography* that is to be dedicated in memory of Bern Megrey, former chair of this ESSAS WG.

The *WG on Climate Effects at Upper Trophic Levels* completed its terms of reference with the publication of a special topic session in *Marine Ecology Progress Series* in 2013 and the WG was terminated.

The *WG on Arctic-Subarctic Interactions* has organized a theme session at the ICES ASC in Spain in September 2014 and a workshop at the PICES annual meeting in Korea in October 2014, both on advection and exchanges between the Arctic and Subarctic.

The *WG on Bioenergetics of Subarctic Fishes* aims to develop deeper understanding of climate's impact on the match between juvenile fish and their prey and the implications of that relationship for future production.

The *WG on Human Dimensions* formed last year under the leadership of Keith Criddle, who gave a presentation at the ESSAS ASM.

The *WG on Comparative Paleo-Ecology in Sub-Arctic Seas* sponsored a special session during the ASM. The WG will explore potential mechanisms linking climate, oceanographic, ecological and human system relationships from the Holocene to the Anthropocene.

Multinational Activities (endorsed by ESSAS)

A Norwegian and U.S. Climate Change and Marine Ecosystems (*NUCCME*) Workshop was held in May 2013 focused on the marine environment, fisheries management and human dimensions, jointly with CLIFFIMA, a Nordic Council Network that investigates climate change issues, including human dimension aspects. A related special issue in *Climatic Change* is in preparation.

The 2011 international Atlantic Multidecadal Oscillation (AMO) workshop published its special issue in the *Journal of Marine Systems* in 2014, describing the temporal variability of the AMO, the spatial structure of the SSTs within the North Atlantic, the possible mechanisms governing the AMO dynamics, the impacts on other physical characteristics such as currents and sea ice, past variability in temperature from paleo-records, the biological impacts of the AMO including effects on phytoplankton, zooplankton and fish stocks, and the links to temperature changes in the Antarctic and the Pacific.

The ESSAS-endorsed project *TROPHARCT* assembled a series of 5 joint papers from Canadian, U.S., Russian and Norwegian scientists plus an introductory paper, published during 2013 in a special section of *Marine Ecology Progress Series* under the title “*Harvested fish stocks in a changing environment*”.

Future ESSAS activities

The next ASM and SSC meetings will be held in June 2015 at the University of Washington in Seattle. In response to a new project initiated at the University of Washington, ‘Future in Ice’, a day to 1.5-day meeting on ice and its effects on biology will be held at the ASM. Additional potential session topics include paleo-ecology, human dimensions, and bioenergetics.

Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) Regional Programme

The ICED programme aims at a better understanding of the climate interactions in the Southern Ocean, the implications for ecosystem dynamics, the impacts on biogeochemical cycles, and the development of sustainable management procedures. www.iced.ac.uk/index.htm.

As part of a thematic workshop, “*Polar Marine Ecosystems Research: Strategic directions for the EU Research Area*” (Brussels, Belgium, May 2013), a joint ICED/EUR-OCEANS Consortium Flagship Project (Polar Ecosystem Change and Synthesis, PECS) strategy document for Polar Marine ecosystem research was presented to senior European Commission members. Such research should form an essential component of the EU Research Area funded by the EC Horizon 2020 funding programme. This is already promoting European and international collaborative research and some of the aims of the strategy have appeared in recent calls of Horizon 2020, thereby fulfilling the workshop's objective.

During the ICED Scientific Steering Committee Meeting (SSC), held in Cambridge, Maryland, USA in November 2013, progress over the last 5 years was reviewed and the key directions and priorities were agreed upon for the next 5 years. The ICED Workshop on ‘Southern Ocean Food webs and Scenarios of Change’ in Nov. 2013, focused on exploring quantitative, future scenarios based on the latest available climate models, ecological data and models, and information on fisheries and the associated critical challenges

The *Workshop on Ecosystem Essential Ocean Variables (eEOVs) for the Southern Ocean*, March 2014, focused on biodiversity indicators and indicators of marine ecosystem structure, function, and dynamics; composite indices; and expert advice to policymaker. A proposal for a related Working Group has been submitted to SCOR.

ICED scientists have participated in the SCAR Horizon Scan Retreat, April 2014, with 80 participants, for identifying the most important scientific questions in and from the southern polar regions over the next two decades. A series of documents have been submitted to the Commission for the Conservation of Marine Living (CCAMLR) Working Group on Ecological Monitoring and Management highlighting relevant ICED science and ways of interfacing with policy.

Several scientific papers were published that consider Southern Ocean change, ecosystem structure and function, links between ecology and biogeochemistry, and management of the Southern Ocean.

One ICED-related session was organised at the IMBER OSC (Bergen, Jun 2014), with a panel discussion on ‘*Challenges for evidence-based management of Southern Ocean ecosystems*’.

The ICED community contributed to the forthcoming IPCC AR5 Report (Climate Change 2014: Impacts, Adaptation, and Vulnerability Working Group II), led by A. Constable.

An ICED stakeholder event (joint with WWF) was held in June 2014, which brought together key sectors with an interest in Antarctic krill: the fishing industry, scientists, and conservation organisations.

Future ICED activities

- A joint AnT-ERA/AntClim21/ICED session on ‘Impact of climate change on Antarctic biota’ will be convened at the SCAR Open Science Conference, Aug. 2014, New Zealand.
- An ICED community paper on scenarios is being developed. ICED will strengthen our science areas as outlined in the IMBER Position Paper and we will work to establish a clear and strong role for ICED within CCAMLR, SCAR and Future Earth.
- The re-development of the online fieldwork map tool is still underway, and a Southern Ocean wiki is developing, led by the ‘Sentinel’ programme.

CLimate Impacts on Oceanic TOP Predators (CLIOTOP) Regional Programme

The CLIOTOP programme aims to use a worldwide comparative approach to identify the impact of both climate variability and fishing on the structure and function of open ocean pelagic ecosystems and their top-predator species. See www.imber.info/CLIOTOP.html.

A *Deep-Sea Research II* special issue developed from the 2nd CLIOTOP symposium is now being edited by CLIOTOP SSC members. CLIOTOP Working Groups have held a range of meetings and have generated a large number of publications. The website hosted by IMBER IPO is allowing us to showcase CLIOTOP scientific outputs (www.imber.info/CLIOTOP.html).

The CLIOTOP SSC held its 9th Meeting in June 2014, in Bergen, just prior to the IMBER OSC. Osamu Abe (Japan) replaced Hideki Nagano (Japan) as an SSC member. Several of the working groups will soon be concluded, and the SSC is now discussing a new structure for a proposed CLIOTOP phase III, for the next five years.

CLIOTOP SSC members convened a workshop entitled “*Beyond ‘Z’: what modelers need and empiricists have to offer to better incorporate higher trophic levels and humans in end-to-end models*” and a session on “*The pivotal role of the mesopelagic functional groups in biogeochemical cycles*” at the IMBER OSC in June 2014, Bergen, Norway.

Selected Working Group Activities

- Co-sponsored session with Marine Bird Mammal – Advisory Panel at PICES FUTURE Open Science Meeting workshop in April 2014 entitled “*Top predators as indicators of climate change: statistical techniques, challenges and opportunities*”.

- “Diet Workshop: analysis of a full stomach contents dataset using classification tree methodology modified for complex diet data”, October 2013, Australia
- “Stable Isotope Workshop: Pelagic Top Predators and N Isotopic Baselines” February 2014, Hawaii, USA
- Website developed for ISOZOO programme investigating the role of lower trophic level dynamics in structure of pelagic food webs: <http://www.iso-zoo.org>.
- The CLIOTOP Scenario Group (involving also representatives from industry and RFMOs) first met in November 2013 and started to establish Oceanic System Pathways (OSPs). The objective is to develop model-based scenarios jointly with stakeholders.
- Participation in the IUCN workshop “*Multidisciplinary Workshop to Address Ecosystem-Level Impacts of Fisheries Bycatch on Marine Megafauna: Biodiversity Conservation through Mitigation, Policy, Economic Instruments, and Technical Change*” in October 2013; in the ‘*Building 21st century scenarios for global oceanic ecosystem and fisheries*’ meeting, in November 2013.
- Participation in several meetings about fishing capacity in various regions, with the International Seafood Sustainability Foundation, the European Commission, or the Inter-American Tropical Tuna Commission.

Science Highlights

CLIOTOP is now becoming better recognized within the open ocean research community, with increasing balance in research between tuna and fisheries, and non-exploitation issues with other top predators (seabirds, marine mammals and turtles).

Results from CLIOTOP activities were published in a special issue of *Deep-Sea Research II*, on the “Role of squids in pelagic ecosystems” (2013).

Future CLIOTOP activities

- Workshop on “Variability in the movement patterns of marine predator populations: physiological, behavioural and environmental drivers in the Bio-logging 5 Symposium, September 2014.
- Several sessions proposed for the ICES/PICES 3rd International Symposium on Climate Change Effects on Marine Ecosystems, March 2015.
- Participation in the Euro BASIN workshop ‘Futures of the North East Atlantic Ocean by 2040- a Stakeholder Consultative Workshop’, November 2014.
- Planned participation in several meetings related to seafood sustainability, fisheries economics and fishery management.
- The 3rd CLIOTOP Symposium is scheduled for September 2015.

Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) Regional Programme

SIBER is a basin-wide research initiative sponsored by IMBER and the Indian Ocean GOOS (IOGOOS) Programme, with close ties to CLIVAR’s Indian Ocean Panel (IOP), and focuses on understanding climate change and anthropogenic forcing on biogeochemical cycles and ecosystems in the Indian Ocean, in order to predict the impacts of climate change, eutrophication and harvesting (www.imber.info/index.php/Science/Regional-Programmes/SIBER and www.incois.gov.in/Incois/siber).

The SIBER SSC met in China, July 2013 following the Second International Symposium on Boundary Currents convened with CLIVAR’s Pacific Panel and Indian Ocean Panel (IOP) and the IndOOS Resources Forum (IRF). A joint session was also convened with CLIVAR/IOP. The International Indian Ocean Expedition 50th Anniversary (IIOE-2) planning efforts have emerged as a major SIBER activity. The second IIOE-2 Reference Group meeting was convened in China, Nov. 2013 to help define the overarching science and societal drivers for IIOE-2, and assess planned and ongoing national activities in the IIOE-2 timeframe (2015-2020). In addition, a strategy was developed for promoting national IIOE-2 planning efforts and an IIOE-2 organizational framework/governance structure was adopted. Another Reference Group meeting needed for the East Africa/SW IO constituency for a more general IIOE-2 engagement was convened in March 2014 in Mauritius. The chair of SIBER, Prof. Raleigh Hood, is chairing a SCOR committee to draft a IIOE-2 Science Plan. This plan will be reviewed at a workshop in Bremen, Germany on 12-13 September 2014.

The Eastern Indian Ocean Upwelling Research Initiative (EIOURI) has also emerged as a major SIBER activity. This initiative, which is envisioned as a 5-year process study and program under the emerging IIOE-2 in the Eastern

Indian Ocean, embraces upwelling as a unifying IIOE-2 theme, with basin-wide relevancy. Three workshops have been convened so far (two in 2013 and one in 2014) with a final workshop was held at the IMBER Open Science Conference, June 2014.

SIBER-motivated biogeochemical sensor deployments are continuing in the Indian Ocean. A biogeochemical sensor package deployed on a RAMA mooring at the equator and 80°E on 22 May 2010 was recovered and the data have been analyzed. In addition, a CO₂ sensor package has been deployed in the Bay of Bengal with support from BOBLME, and a RAMA mooring has been deployed at the flux reference site at 26°S, 97°E equipped with a BGC sensor. Finally, a new SIBER/CSIRO Australian research initiative in the Eastern Indian Ocean is aimed at quantifying nutrient fluxes through the Indonesian Throughflow.

In addition to the SIBER International Project Office, located at INCOIS in Hyderabad, India, efforts are continuing to establish a Regional Program Office in Western Australia supported jointly by Australia's Integrated Marine Observing System (IMOS) and the IOC Office in Perth. The SIBER SSC has provided guidance documents on how to define responsibilities and tasks of this RPO and partition these between IMOS and the IOC Perth office.

A SIBER-related session on 'Biogeochemical and Ecological Impacts of Boundary Currents in the Indian Ocean' was held at the IMBER OSC in Bergen, Norway, June 2014.

Overall, SIBER has strong collaboration with various regional actors (e.g., Indian Ocean Panel of the Variability and predictability of the ocean-atmosphere system project CLIVAR, and IOGOOS) and in this respect has developed a useful model for CLIVAR-IMBER collaboration.

Future SIBER activities:

- The next SIBER SSC meeting will be convened in Phuket, Thailand, in October 2014, jointly with the IOGOOS Program and the IndOOS Resources Forum (IRF).
- The SIBER special issue in *Biogeosciences* on Current biogeochemical and ecosystem research in the Northern Indian Ocean is still in preparation.

D. IMBER Working Groups and Task Teams

SOLAS-IMBER Carbon (SIC!) Working Group

To oversee marine carbon process studies, there are currently three joint SOLAS-IMBER carbon (SIC!) groups dealing with carbon in the surface ocean systems (SOS), carbon in the interior ocean (IOC) and ocean acidification (SIOA). It has earlier been suggested that the remits of the existing SIC! Working Groups could be revisited to incorporate the topic of the Microbial Carbon Pump in the Ocean, its possible interactions with the existing SIC! WGs, and potentially improve the studies of the various forms, sources, sinks and interactions of all pools of organic matter. It was also agreed that this should be done in collaboration with SOLAS and GEOTRACES.

Surface Ocean Systems (SIC!-SOS)

This working group focuses on data synthesis for the carbon in surface ocean systems (SOS), and on instrumentation and technology development, Voluntary Observing Ships (VOS) and mixed layer sampling strategy.

SIC!-SOS members co-convened with SIC!-IOC and IOCCP, a session on '*The ocean carbon cycle at a time of change: Data syntheses, analyses and modelling*' at the IMBER OSC in June 2014, Bergen, Norway, to focus on surface-to-interior connections.

Interior Ocean Carbon (SIC!-IOC)

This working group co-ordinates international research on interior ocean changes in carbon and biogeochemistry, undertakes synthesis activities, and aims to develop sustainable observing systems, including the addition of oxygen sensors to the international ARGO float programme (ARGO-O₂).

The global synthesis of repeat hydrography initiative is progressing well since 2009 and has made major advances in the last year. The secondary data quality control effort of the GLODAP2 group is nearly completed and the data are planned to be released in June 2014. An ad-hoc steering committee with Masao Ishii (Japan), Jeremy Mathis (USA), Toste Tanhua (Germany), and Nicolas Gruber (Switzerland) was formed at a synthesis workshop in Beijing, held in

conjunction with the 9th International CO₂ conference, to oversee the work to determine the global-scale oceanic accumulation of anthropogenic CO₂ since the 1990s. The synthesis group held a workshop at the 2014 Ocean Sciences meeting in order to discuss the first results and agree on a draft outline of a high-profile paper. The final results will be presented at the IMBER OSC where this synthesis group is organizing a dedicated session on “*The ocean carbon cycle at a time of change: Data syntheses, analyses and modelling*” in partnership with SIC!-SOS and IOCCP. WG2 is also continuing to support the growing Bio-Argo programme, with A. Körtzinger and K. Johnson being in charge of SCOR WG 142 on sensor calibration. This group also held its first workshop at the 2014 Ocean Sciences Meeting.

Ocean Acidification (SIOA)

SIOA co-ordinates international research efforts and synthesis activities in ocean acidification. Within a single decade, ocean acidification research has grown from involving only a few scientists to a research topic that has recently been considered the #1 research front in ecology and environmental sciences. While exciting, this rapid expansion has not been without its problems. For example, it has not been easy for experts to share information and train newcomers from different countries, which is essential to avoiding unnecessary duplication.

The SIOA met in May 2014, in Villefranche-sur-mer and Monaco and SIOA members convened a session on “*Regional responses to climatic and non-climatic drivers in a high-CO₂ ocean*” at the IMBER OSC in June 2014, Bergen, Norway.

The Ocean Acidification International Coordination Centre (OA-ICC), initiated and mainly driven by the SIOA, is now half-way through its first three years of funding (2013-2015). It aims to foster scientific collaboration at the international level, promote best practices, improve observational capacities and databases, and facilitate communication and outreach. The OA-ICC is supervised by a Science coordinator (SIOA's current chair). The OA-ICC advisory board includes all SIOA members. The chair of the advisory board is Carol Turley, another SIOA member. The OA-ICC produced several key products that already have become fundamental building blocks for the ocean acidification research community and to ocean acidification science users, including the OA-ICC web site, www.iaea.org/ocean-acidification; OA-ICC news stream at news-oceanacidification-icc.org; OA-ICC bibliographic database, <http://tinyurl.com/oaicc-biblio>; OA-ICC data compilation at <http://tinyurl.com/oaicc-data> (now containing 409 datasets); an SIOA/IOCCP/CARBOCHANGE comparison study of the seven publicly available software packages that compute marine carbonate chemistry was published in *Biogeosciences Discussions*; and the OA-ICC slide set *Things you should know about ocean acidification*, produced for scientists to facilitate making presentations on ocean acidification to non-scientists <http://www.iaea.org/ocean-acidification/page.php?page=2189>.

Additionally, the OA-ICC helped support international scientific meetings where ocean acidification figures prominently, while also promoting understanding of ocean acidification at non-scientific meetings for international negotiations and discussions. The science meetings included the 2nd Global Ocean Acidification Observation Network (GOA-ON) workshop (July 2013) and the 6th SOLAS summer school (Xiamen, China, summer 2013). Additionally, the OA-ICC organized and funded a data curators' workshop (Monaco, April 2014) to move towards the goal of a “one-stop shop” for ocean acidification data. The OA-ICC brought ocean acidification understanding to policy-makers and negotiators by supporting and helping to run an international exhibition stand that highlighted ocean acidification at the UNFCCC COP19 in Warsaw. The OA-ICC also participated in and provided expertise at a UN Law of the Sea (UNICPOLOS) 3-day meeting on ocean acidification (New York, June 2013) and provided information to delegates through the GOA-ON side event at the GEO Summit (Geneva, Jan 2014).

Future SIOA and OA-ICC activities

The OA-ICC will continue to perform routine operations of data management and bibliographic organization, maintain its web site, and post articles to the new stream. Moreover, there are also plans in 2014 and 2015 to launch intercomparison of calcification and boron-isotope measurements, and discussions are underway to determine if the OA-ICC can provide new and consistent routines to propagate errors and compute buffer factors in the publicly available packages that compute carbonate chemistry. The OA-ICC is now in the advanced stages of planning of two training workshops on ocean acidification in late 2014 in Chile and Italy; in 2015, three others are planned to be held in Southeast Asia, Africa, and the Pacific Islands. Additionally, OA-ICC is helping to organize and fund a natural-social science connection workshop on the socioeconomics of ocean acidification (early 2015) as well as the

3rd international GOA-ON observational workshop (2015). Outreach will continue to grow, especially with regard to policymakers at the next COP meetings in Lima and Paris.

Continental Margins Working Group (CMWG)

The current Continental Margins Working Group (CMWG), co-sponsored by IMBER and LOICZ, held its third meeting before the IMBER Open Science Conference: Future Oceans in Bergen, Norway, June 2014.

As human activities dominate key global processes in the Anthropocene era, there is an urgent need to secure sustainability by implementing transformative governance strategies to safeguard Earth's life-support systems for long-term human wellbeing. Nowhere is this endeavour in greater demand than at the ocean-land interface – the continental margins, which are experiencing a quadruple squeeze:

- Population growth, development intensification and rising demands for energy-intensive resources.
- Ecosystem degradation and loss.
- Rising CO₂, climate change and alteration of marine biogeochemistry and ecosystems.
- Ecosystem tipping points and rapid and irreversible changes in social-ecological systems and societal responses.

In this respect, the CMWG is drafting a perspective paper, currently under review, intended as the manifesto for the great needs in future continental margins research. It stresses continental margins are an engagement arena for global sustainability research and action, because more than one-third of the world population resides within the coastal belts that have a direct dependence on marine ecosystem services in continental margins, which are threatened by multiple stressors, both natural and man-made. With the hope to implement the strategies laid out in the perspective paper in future research activities, a longer paper is also in preparation to expand on the five strategic points, illustrated with examples of real cases:

1. To build knowledge and understanding of social-ecological systems on continental margins that cover the spectrum from ecosystem functioning to exploitable resources, societal values, institutional frameworks and governance regimes;
2. To develop innovative methodologies, strategies, guidance and good practices that identify opportunities to unlock the potential of the resources of continental margins, on a sustainable basis, and promote risk reduction;
3. To design governance regimes that are inclusive, reflexive, adaptive and enforceable;
4. To test alternative place-based institutionalized structures and processes for securing equitable distribution of costs and benefits to users of continental margins while sustaining ecosystems; and
5. To experiment with and establish new research epistemologies, partnerships and practices on continental margins – the frontline of the sustainability crisis in the Anthropocene.

Besides the longer paper, an on-line version of a science plan and implementation strategy (SPIS) for future continental margins research is under development.

Following the IMBIZO III (Jan. 2013) Workshop 1 on “*Biogeochemistry – ecosystem interactions on changing continental margins*”, a special issue entitled “*Biogeochemistry-ecosystems interaction in changing continental margins in the Anthropocene*” is being published in the *Journal of Marine Systems*. The main conclusion is that ecosystem responses to biogeochemical change are complex and impact major margin services, including primary production, fisheries production, nutrient cycling, shoreline protection, chemical buffering, and biodiversity. Despite regional differences, complexities, and uncertain feedbacks, the societal consequences of these changes are unarguably large and mandate coherent actions to reduce, mitigate and adapt to multiple stressors on continental margins.

The CMWG members and colleagues convened two sessions on “*Impacts of anthropogenic stressors and climate change on biogeochemistry-ecosystem in continental margins and feedbacks to earth system and society: Challenges and solutions*” and “*Environmental changes in Eastern Boundary Upwelling Systems: drivers, mechanisms and implications for the ecosystems*” at the IMBER OSC in June 2014, Bergen, Norway.

Future CMWG activities:

- After three years of operation, the CMWG will undergo re-organization. Since IGBP, the common parent organization of IMBER and LOICZ, will stop operation at the end of 2015, CMWG will have to undergo a transformation following the two sponsoring projects. Future continental margins research will make significant contributions to the grand collective effort of transformation toward sustainability in the future.

Data Management Committee (DMC)

The DMC promotes a cooperative data management approach - involving experienced data management specialists, from the start of a project, and training young scientists in good data management procedures. The IMBER Data Management Committee (DMC) is composed by a mix of natural science scientists, sea-going scientists, and data experts.

A Data Management Workshop, co-chaired by C. Chandler, T. O'Brien and A. Piola, DMC members, was held as part of the IMBER Open Science Conference, <http://www.imber.info/index.php/Meetings/IMBER-OSC-2014/Sessions-Workshops/Data-Management-for-IMBER>. In order to facilitate the discussions during the workshop, an online survey was distributed before the IMBER OSC.

The IMBER DMC has recommended that IMBER adopt the Directory Interchange Format (DIF) as a discovery metadata standard. The advantage in using DIF is that records can be easily created and managed through NASA's Global Change Master Directory (GCMD). A customized metadata portal within GCMD has been set up for IMBER, which can be accessed at <http://gcmd.nasa.gov/portals/imber/>, with entries for 32 endorsed projects and related activities.

A survey of the GCMD holdings associated with IMBER is currently on-going to determine which Regional Programmes, Endorsed Projects and Contributing Projects have a suitable metadata record.

The DMC recommends:

- To fully integrate data management activities in all IMBER project-wide events;
- To assure that endorsed projects are prepared to comply with IMBER DM policies; and
- To organize a meeting of data scientists of IMBER-endorsed projects and regional programmes.

Capacity Building Task Team (CBTT)

The CBTT objectives are to enhance marine research capabilities in developing countries, enhance research capabilities globally in relevant IMBER activities, and strengthen graduate education in ocean sciences.

A Workshop held in Shanghai in March 2013 aimed at synthesizing the outputs of an international CB workshop (31 July 31–4 August 2012 in Shanghai, China), to finalize a strategic paper to be submitted to a peer-reviewed journal. This meeting was also dedicated to explore future actions of capacity building for marine research in the Asia-Pacific region.

The main outputs of these CBTT efforts included an *EOS* article (2013) and a synthesis paper on “Developing human capital for successful implementation of international marine scientific research projects” in *Marine Pollution Bulletin* (2013). Capacity building in marine sciences faces several challenges, such as the training in multidisciplinary research, increasing capacity for overall synthesis of scientific data, building the capacity of technical staff, keeping highly qualified personnel in marine scientific research roles, as well as the cross-cultural issues in training and minimizing duplication in training activities. Potential solutions to these challenges are provided, along with some priorities for action aimed at improving the overall research effort.

An IMBER Capacity Building workshop was held as part of the IMBER Open Science Conference (OSC) in Bergen, Norway in June 2014, to gain information, knowledge and experience from participants about how capacity building can be developed to support IMBER science for next 5-10 years. In order to facilitate the discussions during the workshop, an online survey was prepared before the Bergen meeting in June.

CBTT worked together with the IMBER IPO and RPO to secure external funding resources to support the IMBER ClimEco4 Summer School, which will be held at East China Normal University, Shanghai, in August 2014.

Future CBTT activities:

In 2014-2015, CBTT plans to organize a small workshop with 5-6 participants to work on the CB requirements for the future, sustainable IMBER studies. The expected output of this workshop will be a “White Paper”-type report for the new IMBER research agenda for the next 5-10 years.

Human Dimensions Working Group (HDWG)

The HDWG focuses on the interactions between human and ocean systems, and aims to create an integrated and interactive natural-social science marine research community within IMBER.

The first IMBER-ADApT paper was completed and submitted to the *Ghoti* section of *Fish and Fisheries* in November 2013. The special volume of *Regional Environmental Change*, resulting from the HDWG-led IMBIZO III Workshop “*Understanding And Forecasting Human-Ocean-Human Interactions, Drivers And Pressures, With Respect To Global Change*” is in preparation.

IMBER-ADApT templates were revised and starting in September 2013, invitations were sent out to collect more case studies for the development of IMBER-ADApT.

The 4th IMBER HDWG meeting was held in March 2014 in Canada. It was decided to further reduce number of questions in the IMBER-ADApT template, to revise and re-submit the *Ghoti* paper, to prepare several papers on shellfish mortality and on the conceptual approach to typology, and to develop a book on IMBER-ADApT case studies. Some changes in the HDWG leadership are anticipated in the future. One HDWG member, Sarah Cooley, stepped down in April 2014, due to a new job situation. One of the new IMBER SSC members, Eddie Allison, became a HDWG member in June 2014.

HDWG members and colleagues convened two sessions entitled “*Responses of society to marine and global changes as a core mandate for IMBER: ways forward*”, with co-sponsorship of PICES, and “*Future Oceans’ stewardship: roles, responsibilities and opportunities in small-scale fisheries*” at the IMBER OSC in June 2014, Bergen, Norway, and one of the HDWG co-chairs (Alida Bundy) gave a plenary presentation during the OSC.

Future HDWG activities:

- Next HDWG meeting planned to coincide with the PICES meeting in Santos City, Brazil.
- Hold workshop prior to the Too Big to Ignore (TBTI) meeting in Merida (Sept. 2014).

E. _____ IMBER project-wide activities

Open Science Conference (OSC) 2014

The IMBER Open Science Conference, ‘*Future Oceans – Research for marine sustainability: multiple stressors, drivers, challenges and solutions*’, held from 22-27 June 2014 in Bergen, Norway (www.imber.info/index.php/Meetings/IMBER-OSC-2014), provided a venue to the larger marine science community for presenting key findings of IMBER-relevant research, for promoting integrated syntheses of IMBER research, and for developing a new research agenda to guide future marine biogeochemistry and ecosystem research.

The OSC helped disseminate IMBER science results to a broader community, with both natural and social science representation. The plenary presentations were broadcast live and subsequently posted on the IMBER website. Social media outlets (mainly Twitter) facilitated the involvement of a wider audience of marine researchers and research end-users, allowing a broader engagement in the strategic discussions.

Overall, the IMBER Open Science Conference attracted more than 720 contributions and gathered about 485 participants representing 46 countries, including 16 developing countries. The final programme included 5 plenary sessions, 11 workshops and 21 contributed sessions, representing all IMBER science themes, regional programmes, working groups, and related communities, with a total of 140 poster and 325 oral presentations. Results from the OSC will be published as peer-reviewed synthesis publications and special issues with contributed and solicited papers.

SCOR agreed to support the participation of several researchers from developing and emerging economies. Other sponsors included the following:

- Research Council of Norway (RCN);
- Institute of Marine Research (IMR), Bergen, Norway;
- University of Bergen (UiB), Norway, Norwegian Research School in Climate Dynamics (ResClim), and the City of Bergen, Norway;
- the State Key Laboratory of Estuarine and Coastal Research (SKLEC), East China Normal University (ECNU), Shanghai, China;
- the U.S. National Aeronautics and Space Administration (NASA);
- U.S. Ocean Carbon and Biogeochemistry (OCB) Program;
- Korea Institute of Ocean Science and Technology (KIOST);
- Academia Europaea (AE);
- European Geosciences Union (EGU);
- European Space Agency (ESA);
- International Council for Science (ICSU), Future Earth (FE) programme;
- Gordon and Betty Moore Foundation (GBMF).

Several sessions and workshops are co-sponsored by the following organisations and initiatives, including the Earth System Governance (ESG) project, Future Ocean Alliance (FOA), International Council for the Exploration of the Sea (ICES), North Pacific Marine Science Organization (PICES) and Variability and predictability of the ocean-atmosphere system (CLIVAR) project. Finally, several exhibitors contributed to the success of this event, including Aquatic Biosystems, Marine Harvest, National Geographic and Sea-Bird Electronics.

The funding provided by external sponsors aimed especially at facilitating participation of early-career researchers (32 were supported), thereby providing these individuals the opportunity to experience international science and to learn about advances in marine science that are being made as part of IMBER activities. They are potentially the next generation of leaders in marine science and entraining them in international science at an early stage benefit them and the larger marine research community, and helps ensure that all regional communities are an integral part of planning the future directions of a marine global environmental change research agenda.

ClimEco Summer Schools

IMBER ClimEco Summer Schools are held every two years and have proved to be a successful capacity building mechanism for students and early-career scientists. The ClimEco4 Summer School titled, '*Delineating the issues of climate change and impacts to marine ecosystems: Bridging the gap between research, assessment, policy and management*', will be held in early August 2014, in Shanghai, China (www.imber.info/index.php/Early-Career/IMBER-Summer-Schools/ClimEco4-August-2014-Shanghai-China). It will focus on indicators that inform us about the impact of global change on marine ecosystems and the human populations that depend on them, and on how to combine them so that they can be used to inform policy and decision-making.

Topics covered in lectures include an overview of climate change impacts on marine ecosystems from a biophysical and human perspective, information about indicators, models, analysis, linking indicators to a regulatory or management perspective, and bridging the gap between research and information that is practically useful for management. Practical sessions each afternoon will enable participants to try out the methods and techniques covered in lectures. Several participants are providing datasets, which will be augmented with additional data if necessary, so groups can select indicators and use them to evaluate the state of a system or species. Students will present their results at the end of the course.

Sixty-four participants from 30 countries were selected from the almost 170 applications received. The Scientific Committee on Oceanic Research (SCOR) agreed to support the participation of several researchers from developing and emerging economies.

The multidisciplinary lecturers are natural and social scientists: Alida Bundy (DFO, Canada), Laura David (University of the Philippines, Philippines), Beth Fulton (CSIRO, Australia), Eric Galbraith (McGill University, Canada), Xianshi Jin (Yellow Seas Fisheries Research Institute, China), Scott Large (NOAA, USA), Stéphane

Pesant (University of Bremen, Germany), Keith Sainsbury (CSIRO & University of Tasmania, Australia), Rashid Sumaila (UBC, Canada) and Ingrid van Putten (CSIRO, Australia).

China-Japan-Korea (CJK) IMBER Symposia

The 6th China-Japan-Korea (CJK-6) IMBER Symposium focusing on “*Ocean Ecosystem Dynamics and Integrated Marine Biogeochemistry and Ecosystem Research*” was held in October 2013, Tokyo, Japan

(www.imber.info/index.php/Meetings/IMBER-Sponsored-and-Endorsed-Meetings/2013/6th-China-Japan-Korea-IMBER-Symposium-3-4-October-2013-Tokyo-Japan), with the following goals:

- To advance our understanding of marine biogeochemistry and ecosystem dynamics for the sustainable use of ecosystem services;
- To understand the response of various marine ecosystems to multi-stressors and drivers, from climate change to anthropogenic forcing.

More than 50 IMBER scientists from the three countries participated in the Symposium, with 30 oral presentations and 16 posters showing IMBER-related research achievements.

A meeting report, ‘*Changes in Marine Environments and Responses of Ecosystem Dynamics in the East Asian Pacific*’, was published in *Eos* in February 2014 (DOI: 10.1002/2014EO070007), and the IMBER Update Newsletter issue n°25 included several science highlights from CJK-6.

Austral Summer Institute XIV

IMBER co-sponsored the Austral Summer Institute XIV (ASI XIV, www2.udc.cl/oceanoudec/asi-14/eng), held in January 2014 in Concepcion, Chile, which focused on *Coastal and Open Ocean Studies through Multiple Approaches*. One of the courses was taught by Kay-Christian Emeis (CMWG member), dealing with “Changing biogeochemical cycles in the coastal ocean”. Nineteen students, from Argentina, Chile, Brazil, Belgium, Colombia, Cuba, Germany, Uruguay and USA, attended.

Status of the International Project Office (IPO, Norway)

The IPO is hosted until April 2017 by the Institute of Marine Research (IMR) in Bergen, Norway. The IMR has recently indicated that the IPO should be soon relocated, more closely to the management team of the new formed *Johan Hjort Centre for Marine Ecosystem Dynamics*, sponsored by four Bergen institutions: the Institute of Marine Research, the Nansen Environmental and Remote Sensing Centre, the University of Bergen and its spin-off, Uni Research Ltd. This pro-active, positive aspiration is a positive sign and will be carefully considered and valued.

Continuation of the IMBER Regional Project Office (RPO, China)

The IMBER Regional Project Office (RPO), established under a Memorandum of Understanding between IMBER and its host institution, the East China Normal University, in 2010 for an initial three-year period, has been renewed for another three years (2013-2016). The RPO is an essential facilitator in the IMBER efforts to reach out to the IMBER-related research community in the Asia-Pacific region, and a very active partner with the International Project Office in many of its activities.

F. _____ IMBER SSC membership

There are currently 15 IMBER SSC members. At the end of 2013, Javier Aristegui (Vice Chair), Carol Robinson (Vice Chair), Jean-Pierre Gattuso and Nicolas Gruber completed their second term of office on the SSC. In February 2013, IMBER solicited the research community for nominations for their replacements with the following expertise, identified by the IMBER Executive Committee: human-ocean interactions, marine anthropology; marine/environmental economics; microbial ecology and biogeochemistry, meso-pelagic processes; carbon fluxes and budgets; biogeochemical modelling, carbon-climate interactions and ocean acidification. Fifty-seven submissions were reviewed extensively and a short list of nominees presented to and later approved by SCOR and IGBP in late 2013: Edward H. Allison (M, US), expertise: human-ocean interactions, marine anthropology; Katrin Rehdanz (F, DE), expertise: marine/environmental economics; Gerhard J. Herndl (M, AT), expertise: microbial ecology and biogeochemistry, meso-pelagic processes; Laurent Bopp (M, FR), expertise: carbon fluxes and budgets; biogeochemical modelling, carbon-climate interactions and ocean acidification.

N.B.: the country codes mentioned after the names refer to the current country of affiliation of the nominees, not

necessarily their nationality.

At the end of 2014, Ken Drinkwater, Eugene Murphy, Hiroshi Ogawa, Alberto Piola and Sinjae Yoo will complete their second term of office on the SSC. Nominations for replacements were solicited from the research community through a call for nominations disseminated in March 2014. The required fields of expertise identified by the IMBER Executive Committee are:

- physical oceanography, satellite oceanography and climate interactions in changing marine environments
- marine biogeochemical cycles, and dynamics of organic matter and nutrients in changing marine environments,
- biological and ecological oceanography, and ecosystem dynamics in changing marine environments, and
- integrated studies of social, ecological and biogeochemical marine systems.

Fifty-one nominations were received and reviewed by the IMBER Executive Committee. A short list of 6 possible SSC candidates with the expertise that will be required by IMBER in the future was discussed during the SSC meeting in June 2014.

To more evenly distribute changes to the IMBER SSC, it was agreed to extend Eugene Murphy and Alberto Piola for one more year and continue Ken Drinkwater as an ex-officio member. This decision was made in consultation with the IMBER co-sponsors. This arrangement will avoid large changes in the SSC membership, especially now that IMBER is undergoing a transition and organization of the GEC projects is changing. The SSC discussed potential nominees for the three open positions. Discussions are ongoing and once the nominees have confirmed their interest in participating in the IMBER SSC, their nominations will be provided to SCOR and IGBP. It is anticipated that the nomination process will be completed in August.

G. IMBER cooperation

IMBER has been closely collaborating for many years with SOLAS (see SIC!) and LOICZ (see CMWG) and have ongoing joint activities. The IMBER-CLIVAR joint activity is relatively new and is now beginning to develop its own identity as described below.

Cooperation with the ‘Variability and predictability of the ocean-atmosphere system’ project (CLIVAR) on the IMBER/CLIVAR Joint Research Initiative on Upwelling

In 2013, a WG was assembled under the leadership of Ken Drinkwater to undertake joint research by CLIVAR and IMBER on upwelling ecosystems. One member from SOLAS was also included. This team was asked to develop an implementation plan to tackle 2-3 issues of joint interest through workshops and/or working groups. A research effort directed at upwelling in the Eastern Indian Ocean has been initiated through the joint efforts of IMBER’s SIBER programme and CLIVAR’s Indian Ocean Panel. Two workshops were held in 2013 to develop a Science Plan and Implementation Strategy and a third workshop entitled “*Eastern Indian Ocean Upwelling Research Initiative Planning Workshop Phase 3 – Physical Dynamics and Ecosystem Responses*”, and two sessions on “*Environmental changes in Eastern Boundary Upwelling Systems: drivers, mechanisms and implications for the ecosystems*” and “*Climate-biogeochemistry interactions associated with open-ocean oxygen minimum zones*” were co-convened by IMBER and CLIVAR researchers during the IMBER Open Science Conference in Bergen, June 2014.

Future IMBER-CLIVAR-related activities:

A workshop aiming at investigating the potential effects of climate change on upwelling systems will be held in conjunction with the PICES/ICES/IOC 3rd Symposium on Climate Change in the World’s Oceans in Brazil in March 2015. The most recent global and regional models will be used to determine future scenarios in the upwelling regions of the world’s oceans. These, together with information on the present trends in upwelling, will be used to determine the likely impacts on the primary and secondary production and further on fish and fisheries. Output from the workshop will be a report to IMBER, CLIVAR and SOLAS, as well as a primary publication comparing and contrasting the physical and biogeochemical (e.g., oxygen) scenarios in the major upwelling regions of the world under future climate change.

There is also a plan for further joint collaboration. Comparative studies will be conducted on major upwelling areas around the globe, for example, within eastern (EBCs) and western boundary currents (WBCs), along the equator, in the Indian Ocean, in polar regions, etc. and will cover physical, biogeochemical, biological, fish and fisheries processes and trends. Projection scenarios will be developed based on global and higher resolution regional models. Of major importance will be potential effects on fisheries resources that, in turn, will be used to explore the effects of different management strategies under climate change in order to maximize societal benefits. The results will be published in primary scientific and socio-economic journals together with research recommendations to improve estimation of ecosystem changes in upwelling regions under climate change and the potential effects on their dependent societies.

It should also be noted that IMBER has strong links with the observations community:

Indian Ocean Global Ocean Observing System (IOGOOS)

SIBER (under the sponsorship of IMBER and IOGOOS), the kindred physical oceanography alliance known as the Indian Ocean Panel of GOOS/CLIVAR (IOP), the IndOOS Resources Forum (IRF) (supporting SIBER and IOP in strategic and operational terms), are stimulating progress in specific components of GOOS contributing to building IndOOS, such as the Argo programme, XBT, SOOP, satellites, buoys etc. SIBER is especially involved in the on-going deployment of biogeochemical sensors on Indian Ocean Observing System (IndOOS) / Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA). Under the IOGOOS framework, relevant activities focus on issues of local or global importance, such as monsoons and ENSO, and also include capacity building, modelling and forecasting.

Contributions to international assessments

- Many SIC!-related research projects have contributed to a series of synthesis chapters for the Regional Carbon Cycle Assessment and Processes (RECCAP) effort (www.globalcarbonproject.org/reccap/).
- Many of these syntheses and other contributions from the IMBER-related research projects and IMBER regional programmes are included in the *fifth Intergovernmental Panel on Climate Change Assessment Report (AR5)* of the Intergovernmental Panel on Climate Change' (IPCC, www.ipcc.ch). IMBER-related researchers markedly who are significantly involved in the IPCC AR5 Work include Nicolas Bates, Laurent Bopp, Andrew Constable, Sarah Cooley, Scott Doney, Kenneth Drinkwater, Richard Feely, Jean-Pierre Gattuso, Nicolas Gruber, Christoph Heinze, David Karl, Corinne Le Quere, Salvador Lluch-Cota, Yukihiko Nojiri, James Orr, Svein Sundby, Toste Tanhua, Carol Turley, and Rik Wanninkhof.
- IMBER researchers are involved in the United Nations 'Regular process for global reporting and assessment of the state of the marine environment, including socio-economic aspects', aka, UN World Ocean Assessment (UN-WOA; www.worldoceanassessment.org).
- IMBER has provided comments on the European Space Agency (ESA) science strategy (2006), as inputs to the *ESA Living Planet Symposium* (www.livingplanet2013.org) that took place in September 2013, Edinburgh, UK.
- IMBER has also contributed to the activities of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, www.ipbes.net), especially through nominations of IMBER-related researchers for relevant IPBES activities and committees.

H. Selection of IMBER Publications

Overall, IMBER has produced about 1000 refereed research papers since its implementation, including about 150 papers and 12 special issues published in 2013-2014.

Special Issues

Canadell, J., P. Ciais, C. Sabine, and F. Joos (2013). REgional Carbon Cycle Assessment and Processes (RECCAP). *Biogeosciences*, 9-11 (special issue 107) - www.biogeosciences.net/special_issue107.html

Cowie, G., H. Kitazato, R.H. Hood, S.W.A. Naqvi, and A. Gooday (2013). Current biogeochemical and ecosystem research in the Northern Indian Ocean. *Biogeosciences*, 10-11 (special issue 138) - 6 papers. www.biogeosciences.net/special_issue138.html

Denman, K., R. Feely, J.-P. Gattuso, H.-O. Pörtner, U. Riebesell, D. Schmidt, and A. Waite (2013). The ocean in a high-CO₂ world III. *Biogeosciences*, 10 (special issue 129) - 19 papers. www.biogeosciences.net/special_issue129.html

- Drinkwater, Ken and Pierre Pepin (2013). Norway-Canada Comparison of Marine Ecosystems (NORCAN). *Progress in Oceanography*, 114, 1-126. www.sciencedirect.com/science/journal/00796611/114
- Landry, Michael R. and Michio J. Kishi (2013). Sensitivity of marine food webs and biogeochemical cycles to enhanced stratification. *Progress in Oceanography*, 119, 1-108 - [10 papers](#). www.sciencedirect.com/science/journal/00796611/119
- Liu, K.-K., C.-K. Kang, T. Kobari, H. Liu, C. Rabouille, and K. Fennel (2013). Biogeochemistry and ecosystems in the western north Pacific continental margins under climate change and anthropogenic forcing. *Biogeosciences*, 10-11 (special issue 125) - [23 papers](#). www.biogeosciences-discuss.net/special_issue105.html
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Communication and Outreach

The IMBER Website, www.imber.info, remains our main communication tool, with an average of about 250 unique visitors per day. It has received a lot of attention during the last reporting period because of the Open Science Conference.

The *IMBER Update Newsletter*, www.imber.info/index.php/News/Newsletters, is emailed to ~1,600 scientists three times a year, and re-directed through multiple channels to about 10,000 researchers:

- **Issue n°26** – May 2014, included articles about ESSAS and Arctic and Sub-Arctic research, Anoxia in the Far Eastern Marine Biosphere Reserve (Peter the Great Bay), Ocean Colour for Climate, the Austral Summer Institute XIV (ASI XIV) at University of Concepción, Chile, the comings and goings of IMBER members, and recent IMBER publications and events
- **Issue n°25** - December 2013, included articles about Science highlights from the 6th China-Japan-Korea IMBER Symposium (3-4 October 2013, Tokyo, Japan), the CLIoTOP *Deep Sea Research II* volume on the role of squids in pelagic ecosystems; the IMBER endorsed project INCT-TMCOcean and some announcements about the IMBER Open Science Conference and the IMBER ClimEco4 Summer School
- **Issue n°24** - August 2013, included articles about Science highlights from IMBIZO III, new endorsed project and the endorsed project POMAL

The IMBER *eNews Bulletin* is published electronically every month, providing information about IMBER and IMBER-relevant activities and events. Calls for funding proposals, job opportunities, and workshop and conference announcements are also included.

The IMBER contact database is continuously improved, with about 10,000 email contacts, and detailed information for about 1,800 marine researchers.

The IMBER IPO *YouTube* channel was opened in October 2012 to disseminate the ClimEco3 *e-lectures*, www.youtube.com/channel/UCinzjRz7_TKHESn6uggCKlw and has gathered so far more than 2,500 views. Recently, an IMBER *twitter* channel, https://twitter.com/imber_ipo has been developed. The IMBER OSC plenary presentations have also been recently uploaded for further dissemination.

The IMBER GCMD metadata portal has already been mentioned earlier (see DMC section).

Finally, the IPO and RPO staff and several IMBER researchers have presented more than a dozen IMBER poster and oral presentations at many national and international meetings.

I. Support from SCOR

IMBER greatly appreciates the ongoing, key support received from SCOR, and the additional support to specific IMBER activities (especially OSC 2014 and ClimEco 4) provided by or managed through SCOR, from other funding sources. In addition, IMBER welcomes the advice, assistance and information received from the SCOR President and secretariat, especially its Executive Director, Ed Urban, and Financial Officer, Liz Gross.

J. Strategic development

IMBER is now entering the last year of its initial 10-year science plan. The IMBER science community has clearly indicated a desire for the project to continue. The enthusiasm and support shown at the recent OSC indicated that there is a strong community of researchers engaged in IMBER science. The position paper now being finalized is intended to provide guidance for the development of a new research agenda for the next phase of IMBER research.

The position paper will provide the basis for a request to SCOR for a second 10-year period of IMBER research. The grand challenges and science themes in the position paper are being derived from community inputs and strategic discussions. Thus, this is a reflection of what the IMBER community perceives to be the important research areas.

At the same time, the organizational structure for international global environmental change (GEC) research is changing. The IGBP, which co-sponsors IMBER with SCOR, will end in December 2015 and Future Earth will be operational at this time. Future Earth is intended as a 10-year initiative that is being developed around three themes, Dynamic Planet, Global Development and Transformations toward Sustainability, with a goal of addressing challenges and solutions for global sustainability. The core projects currently sponsored by the IGBP were invited in early 2013 to become core projects under Future Earth.

IMBER has a history of connecting natural and social sciences and promoting integration across disciplines and communities. IMBER is already engaged in research topics that address several of the Future Earth objectives, and many of its coordination and networking activities match the integrated approaches desired by Future Earth. As a result, IMBER is well placed to take the lead in developing marine-focused efforts under Future Earth. The transition to a Future Earth core project should not require additional modifications to IMBER science goals or implementation plan.

As with SCOR, the position paper will form the basis for a request to Future Earth to incorporate IMBER as core project. The request will include a description of what IMBER can bring to Future Earth in terms of science and as an international network of researchers. The request will also include what IMBER expects from Future Earth, such as support for SSC meetings and integrated activities, funding at the same level as provided by SCOR, and some specific assistance provided for fund raising, outreach, communication and engagement of stakeholders. It is anticipated that the formal IMBER request to Future Earth will be made in late Fall 2014.