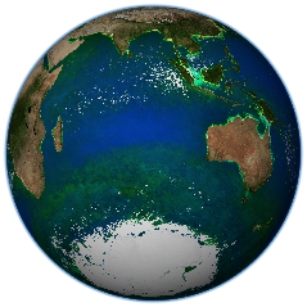

SIBER

Sustained Indian Ocean Biogeochemistry and Ecosystem Research

Report of the 2nd Meeting of the SIBER Scientific Steering Committee

26-28 July 2011

Chennai, Tamil Nadu, India

Integrated Marine Biogeochemistry and Ecosystem Research

IMBER Report # 6

IOGOOS:PR:07:SIBER/03

SIBER Report # 3

The SIBER program reflects the importance placed on these issues by the International Geosphere-Biosphere Program (IGBP), the Scientific Committee on Oceanic Research (SCOR) and the Global Earth Observing System of Systems (GEOSS). SIBER has been developed with the approval of the Integrated Marine Biogeochemistry and Ecosystem Research Program (IMBER) and the Indian Ocean Global Ocean Observing System (IOGOOS), providing strong relevancies to the High Level Objectives of UNESCO's Intergovernmental Oceanographic Commission, which span across the generic themes of marine hazards, climate change, ecosystem protection and associated marine natural resource management.

Bibliographic Citation:

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Introduction

The second annual meeting of the SIBER Scientific Steering Committee (SIBER-2) was held on 26-28 July 2011 at the MGM Beach Resort in Chennai, India. SIBER-2 was held in conjunction with the 8th Indian Ocean Panel (IOP) meeting on 25-26 July and the 2nd IndOOS Resource Forum (IRF) on 29 July. A joint SIBER-IOP session was held in the afternoon on 27 July. On the morning of 29 July, IRF organized a mini symposium on "Challenging scientific issues that are being addressed by IndOOS" that was opened to all participants.

The SIBER SSC members met from the afternoon of 26 July through 28 July. Of the SIBER SSC membership, Catherine Goyet and David Vousden were unable to attend and both communicated their regrets. Tommy Bornman (ASCLME) was able to participate as a proxy for Dr. Vousden. Guest experts participating at the invitation of the SIBER SSC consisted of Zainal Arifin (Research Centre for Oceanography, Indonesian Institute of Sciences), Rudolf Hermes (BOBLME), R. Ramesh and S. Singh (Physical Research Laboratory) and P. N. Vinayachandran (Indian Institute of Science – CAOS).

A foundational component of SIBER is to promote and leverage opportunities to foster international collaborations in Indian Ocean research. Through pursuit of this goal, it is envisaged that the number of participants, institutes and programs involved in Indian Ocean research will expand, with SIBER serving to stimulate the innovation, direction and coordination required to build a critical mass of multidisciplinary science and scientists. SIBER's sister organization, the CLIVAR-IOP has similar core objectives that were recently highlighted by Gary Meyers and Yukio Masumoto (Founding Chair and past Co-Chair of IOP, respectively) in an article on IndOOS that they provided to the Ocean Policy Research Foundation (OPRF), a Japanese think tank. The following statement is extracted from the opening remarks of their brief to the OPRF, and is included here to emphasize the broader influence that both the CLIVAR-IOP and SIBER strive to attain.

"The Indian Ocean has in recent years become a focal point of geopolitical interest and strategic planning for major economic and military powers around the world. The economies of some nations in Asia, Europe and even the America's are critically dependent on the flow of energy and free passage of oil along the shipping lanes of the Indian Ocean. With the rise of China and India as economic powers, a sense of competition and wariness has crept into the strategic planning of many nations with Indian Ocean interests. Prof Sandy Gordon (Australian National University) recently stated that, "What is needed [rather than competition] is a strategy designed to provide for joint action in the "commons", to alleviate the sense of insecurity on the part of the major powers that their legitimate interests in the Indian Ocean might not be met." He goes on to make the point that nations with Indian Ocean interests should work together in the commons to address non-conventional security threats, and specifically mentions a host of environmental and natural disaster challenges among other threats. This is exactly what is happening in the development of IndOOS, and much more can be done as we begin to use the observations to address societal problems."

Review of Accomplishments and Activities since SIBER-1

The inaugural meeting of the SIBER Scientific Steering Committee (SSC) was held in Perth, Australia in 12-16 July 2010, in conjunction with the meetings of the CLIVAR Indian Ocean Panel (IOP), the coordinating members of IOGOOS (Indian Ocean Global Ocean Observing System), and the inaugural meeting of the IndOOS Resources Forum (IRF). Principal accomplishments of the SIBER discussions included formalization of the SSC membership, the confirmation of the SIBER Chair (Hood) and Co-Chair (Naqvi), and the election of the SIBER Secretary (Wiggert). The launch of India's SIBER Program, established earlier in 2010, was reported by the SIBER Co-Chair (Naqvi).

Principal action items identified during the meeting included:

1) Establishment of a SIBER International Program Office (IPO), to be housed at INCOIS and staffed and funded through the generous facilitation of the Indian Ministry of Earth Science (Nayak)
2) Determine how to best leverage the linkage to organizations focusing on ocean carbon studies that already exists between IMBER and SOLAS (Goyet & Rixen)
3) Identification of funding sources to support the outfitting IndOOS sites with biogeochemical sensors. This is a combined SIBER-IOP effort (Hood & Meyers).
4) Establish and maintain initial SIBER website at IMBER IPO, and subsequently transition to SIBER IPO once it is established. Mechanisms need to be established to ensure that web content is regularly updated (Wiggert, Hood & Beckley).
5) Identify members for a working group to be tasked with determining methods and likely approaches for promoting regional capacity building (Wiggert & Cowie)

In November, an interview article featuring the SIBER monograph was published in EOS's Bookshelf section (L. Ofori, EOS, v 91, #44, 02 November 2010). The establishment of the SIBER IPO at INCOIS (Indian National Centre for Ocean Information Services) was accomplished and the SIBER website hosted by INCOIS came online just prior to the SIBER-2 meeting (further details below). Development of the SIBER Science Plan and Implementation Strategy (SPIS) was near to completion, with final editorial inputs coming from members of the SIBER SSC and the considerable facilitation and oversight of Lisa Maddison (Executive Officer, IMBER-IPO, Brest, France).

SIBER IPO and Website

SIBER intends to provide scientific guidance and potential research focus to many countries, including Indian Ocean rim countries, interested in pursuing research activities in the Indian Ocean. Coordination of such a basin-wide research program requires well-organized guidance and oversight by a governing body that is well informed about the scientific questions to address in the Indian Ocean. SIBER scientific steering committee (SIBER SSC) members are providing this guidance. To facilitate information sharing among various international programs and to co-ordinate the activities pertaining to SIBER in different Indian Ocean rim countries, an establishment such as an international program office (IPO) has been established at Indian National Centre for Ocean

Information Services (INCOIS) in Hyderabad, India as a part of IOGOOS secretariat on the advice and guidance of SIBER SSC.

The primary responsibilities of the SIBER IPO are: (i) to provide logistical support for convening SIBER SSC meetings, symposia and workshops; (ii) to develop and maintain SIBER website; and lastly (iii) to develop and distribute the SIBER Newsletter.

Since its inception, the SIBER IPO has made significant contributions to SIBER community. The SIBER IPO has provided logistical support for convening SIBER SSC meetings, conferences and workshops including on-sight meeting support. The SIBER IPO coordinated the SIBER-2 meeting, concurrent with the IOP-8 and IRF-2 meetings during July 25-29, 2011 at MGM Beach Resort, Chennai.

A SIBER website (http://www.incois.gov.in/Incois/siber/siber.jsp) has been established by SIBER IPO that is charged with promoting awareness of SIBER activities, reporting on research opportunities and facilitating the establishment of international collaborations focusing on the Indian Ocean. The web site summarizes the scientific and collaborative goals, potential infrastructure leveraging opportunities, and the research objectives and themes that were identified during the development of the SIBER program. Contact details for the SSC members, as well as participant lists for various SIBER workshops and meetings from the inaugural NIO-hosted workshop in 2006 are also available. Various SIBER related publications/reports, including the science implementation plan, has also been made available and can be downloaded from the website. Additional content will be added over time, including meeting reports, working group activities, overview presentations and links to other relevant websites.

It is also planned to establish the SIBER Newsletter, proposed to be published and distributed semi-annually to communicate SIBER activities and other relevant information about Indian Ocean research and monitoring programs to the researchers having SIBER-related interests. SSC members will act as the editorial team. The 1st newsletter is expected during mid 2012.

Contact details for Dr. Satya Prakash, who coordinates the activities of the SIBER-IPO, are as follows:

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Phone : 91 40 2388 6093
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satyap@incois.gov.in

Discussion Points:

Goal: Have site function as a way to actively engage international partners in research opportunities. Steer reader toward how to engage in IO research. See what other groups are doing around IO. Identify ways toward potential collaborative links. Need to go

global. How to promote realization of the site as a mechanism for promoting development of collaborative efforts?

Possible Functions: Forum for posting job opportunities. Informing community of SPIS publication.

General Points: Discussion of form and content for SIBER Newsletter. Define an editorial committee. Template is ready and is based on earlier newsletters generated by Wiggert. Should publication be quarterly or biannual? Should issue be printed or online accessible (only)?

Hood: Need SSC input on website content (FOLLOW UP AND PING FOR INPUT)

Beckley: Include page or two of hot topics/breaking developments.

Combined bottom up and top down development of funding/collaborative opportunities. Website can facilitate promotion of grass roots development, can then be a great example to show to program managers to demonstrate international interest.

Hermes: Suggest having profiles of SSC members. This would be useful as an informational tool for students with potential interest in SIBER-related research projects or participating in SIBER-organized activities. NOTE: IMBER-SIBER page has a template in place, which shows SIBER membership with brief bio, contact information and thumbnail photo. This form could be adopted for the INCOIS-hosted SIBER portal.

Cowie: Featuring the SIBER regional activities, such as SIBER-India and ongoing Australian efforts, would be useful as confirmation of an existing framework that will have appeal for national programs (e.g., NERC). Demonstrating an established research infrastructure will promote interest in the program managers who want to see how they may leverage other ongoing activities.

Action Item: Develop email list of broader SIBER community for distributing newsletter publication notices and for disseminating information on opportunities of interest. Tap into WIOMSA, ASCLME, AMSA, BOBLME and NERC (and others) for developing SIBER interested community.

Working Groups

Establish a Web/Newsletter Subcommittee (Naqvi/Cowie/Landry/Wiggert)

Action Item: Task is to identify who to tap for specific input on topics that should be promoted within the newsletter/website framework.

Working Group: Identification and Pursuit of Funding Opportunities

All members of the SIBER SSC have been tasked with exploring possible funding avenues in their national or regional locales. This should be considered as a continually ongoing activity. These could entail leveraging the SIBER program as a visible venue for enhancing individual projects through the international collaborations it can facilitate. Given that the travel funds provided by the IMBER steering committee and the IOC-Perth Office are insufficient to cover the costs of the full SIBER SSC to attend the annual meetings, all SSC members are encouraged to identify and pursue supplemental sources that may be identified.

Development of coordinated proposal clusters with high national and international visibility, as exemplified by the establishment of the SIBER – India activity, is a promising mechanism that would significantly enhance SIBER's establishment and future prospects. Pursuing such national or multi-national (regional) partnerships by the SIBER SSC members is strongly encouraged, when such opportunities are identified. As an initial step toward attaining such outcomes, the nominal charge for national/regional groups is to develop a working group that is recruited from outside the SIBER SSC membership. The national/regional distribution of the SIBER SSC membership is summarized below.

Nation/Region	SSC Members
European Union	Cowie/Rixen/Goyet
United States	Landry/Wiggert/Hood
Australia	Beckley
Western IO	Vousden/Adam/ Bhikajee
Northern AS	Al-Azri
Eastern IO	Susanto/Arifin
Japan	Kitazato

Discussion Points:

SIBER-Japan local working group (in progress)

Hiroshi Kitazato (deep-sea biology); **Toshitaka Gamo** (inorganic geochemistry) GEOTRACES steering committee; **Toshiro Saino** (organic geochemistry) Joint IMBER/SOLAS Carbon Research Working Group; **Ken Takai** (microbial ecology)

Membership of SIBER-Japan WG remaining to be identified with expertise in: Coastal Hypoxia and OMZ; Physical Oceanography; Biogeochemical Sensors.

D'Adamo: Food security initiatives may be a funding pathway. Request more information in terms of what are the contacts for such organizations!

D'Adamo: Develop a funding resources plan for SIBER. Identify potential funding sources.

Wiggert: Essentially this has been the charge of SSC members from various countries, though primarily the thought process was to approach program managers of various funding agencies. A more diverse complement of potential sources should be considered to accomplish the supplemental support goal.

Wiggert: Should consider all Indo-XX bilateral agreement organizations that may be approached for supplemental funding. For US, example is IndoUS STF. There are also Australian, German and French equivalents.

Koblinsky: Approach to NOAA (i.e., their research interest) should be the long-term climate impacts issue. He cites example of the scientific issues raised in Tim's IRF presentation as being attractive to their perspective. This may be a foothold that would be tractable in terms of obtaining NOAA funding.

D'Adamo: Explore what organizations may be willing to kick in funding. For example, BP may kick in travel support given their interest in Australian resources currently being developed along NW Australian Shelf.

Wiggert: What about looking to SCOR (i.e., Ed Urban) for supplementing SSC meeting support, regardless of whether the IMBER funding is lost or scaled back.

Working Group: Review/Evolve SIBER SPIS Scientific Themes

For the six scientific themes set out in the SIBER Science Plan and Implementation Strategy (SPIS, http://www.incois.gov.in/Incois/siber/siber.jsp), the lead editors of these themes in the SPIS (see below) have been identified as working group leaders charged with maintaining and refreshing the scientific themes that are the cornerstone of SIBER's research directives. Through this activity, research pathways that are revealed as the SIBER program evolves and matures would be highlighted and promoted to the broader oceanographic community.

Theme #	Lead Editor	Theme Topic
1	Beckley	Boundary Current Interactions and Impacts
2	Wiggert	Ecological and Biogeochemical Variability resulting from dynamics of the EQIO, STIO and ITF
3	Rixen	Contrasts between the AS and BoB
4	Cowie	Pelagic and Benthic Production in the IO
5	Goyet	Climate and Anthropogenic Impacts on the IO
6	Landry	Role of Higher Trophic Levels

Discussion Points:

Hood: Discussion of 2-page proposal for access to Australian Ship to perform repeat of IIOE line in 2015 (50th anniversary)

Hood: SCOR (Ed Urban) is interested in holding a major symposium to mark 50th anniversary of IIOE. Idea is to hold this at India's National Institute of Oceanography in Goa (established as part of IIOE capacity building program).

Review of Science Plan Themes

Theme 1: Beckley

Boundary current dynamics, interactions and impacts on biogeochemistry and ecology

Agulhas Current portion of the SPIS is weak. Need to strengthen the biogeochemical aspects. IOP members (de Ruijter) are pushing for an additional component to the RAMA array. Some question as to how much biogeochemical research is actually ongoing. Proposal for a Chapman conference in South Africa. That SIBER is looking to link into for next SSC meeting. Bornman states that on board de Ruijter cruises, there is little biogeochemical observations being obtained.

What is the impact of reversing currents on Mauritius fisheries?

Naqvi: Dust deposition region extending off SE tip of African continent that is then under influence of the Agulhas Current. How strongly does this influence the chlorophyll feature that extends into retroflection?

Theme 2: Wiggert

Dynamical variability of the equatorial zone, southern tropics and Indonesian Throughflow and their impacts on ecological processes and biogeochemical cycles

Need to better characterize and understand the many unique aspects of the Indian Ocean circulation in the equatorial zone and southern tropics and the ecological and biogeochemical responses to the physical forcing.

Questions about the role of iron limitation extend over the entire basin. A fundamental need is to explore and characterize when and where supply of dissolved iron limits phytoplankton production in the Indian Ocean. What are the biophysical mechanisms that prescribe this supply?

Analyses of remote sensing data illustrate that intra-seasonal variability in SST and Chl arises from two sources: small-scale (< 50-100 km) eddies, and large-scale coherent atmospheric forcing associated with the Madden-Julian Oscillation. The remote sensing data indicate two hot spots of intraseasonal variability: one is in the SCTR and has been a focus of recent studies; the second is in the Throughflow region and is a more prominent feature but has received little attention.

Another intriguing aspect of the Indonesia-Australia corridor is the pronounced salinity heterogeneity that results from runoff in the Indonesian Archipelago contrasting against the Pacific waters that propagate westward through the Throughflow (cf., Animation of surface salinity from the GFDL CM 2.4, Vecchi). The mixing of these low and high salinity source waters are suggestive of how biogeochemical transports within the ITF manifest.

Theme 3: Rixen

Physical, biogeochemical and ecological contrasts between the Arabian Sea and the Bay of Bengal

Monsoon intensification: Literature check shows discussions going on as to whether intensified coastal upwelling in east boundary systems has a direct and identifiable linkage to biogeochemical impacts. Similar to Arabian Sea case, i.e., monsoon intensification argument of Goes, which is not clearly established, and its link to productivity during SW Monsoon is in question.

Theme 4: Cowie

Controls and fate of phytoplankton and benthic production in the Indian Ocean

Cowie on Q1: 1) What is influence of ITF on basin wide nutrient budget (directed toward Hood et al. modeling that shows OMZ influenced by ITF BC). 2) Contrasting of Arabian Sea and Bay of Bengal in terms of freshwater input relative to water column stratification.

Cowie on Q2: Additional topic. Expand on emphasis of societal relevance and stress the impacts of coastal hypoxia that is sensitive to climate and anthropogenic influences. Water column in Bay of Bengal is potentially on verge of transitioning to full hypoxia.

Kitazato: Bay of Bengal has benthic efflux of methane that is of interest and not well characterized.

Cowie: Arabian Sea and Bay of Bengal coastal margins represent 2/3 of prominent coastal hypoxia regions worldwide.

Cowie: Chemosynthetic processes are of importance and not treated in the SPIS. Related issues: Bacterial mats, annamox,

Theme 5: Hood (for Goyet)

Climate and anthropogenic impacts on the Indian Ocean and its marginal seas

Note: Acidification is incorporated into theme 5.

D'Adamo: WAGOOS is heavily tied into the marine industries (i.e., oil industry in particular). Oil platforms do have observational systems and in situ studies that are available as long as they are not proprietary in terms of functioning of the oil rigs

D'Adamo: Consider developing a comparison of coral communities across southern Indian Ocean (West Australia vs. Madagascar).

Adam: Maldives and Mauritius also have coral systems and societal impacts/influences that should be accounted for in any exploration of ocean acidification effects.

Hermes: Ocean acidification impact on corals also translates up to higher trophic levels. Pelagic populations are heavily affected.

D'Adamo: Regarding SIBER becoming better recognized in the ocean carbon community. Kathy Tedesco is in leadership role and could be tapped for guidance.

Hermes: Regarding land-based sources of pollution, Global Partnership on Nutrient Management (GPNM, http://www.gpa.depiconnect.org/gpnm.html) is UNEP program of relevance.

Hermes: Should SIBER place stronger emphasis on aquaculture investigations and nutrient issues?

Wiggert: Linkage to IMBER/SOLAS Carbon group should be emphasized, which should be possible given that Richard Matear is a member.

Theme 6: Landry

Role of higher trophic levels in ecological processes and biogeochemical cycles

Q1: Understanding control points for how planktonic ecosystems are structured are highly relevant (but broad) and regionally non-specific. Obtaining field validated rates are a critical need for modeling efforts.

Landry et al. NSF-funded project for AS was diverted to Eastern Tropical Pacific. So long term plan is to follow through on the funded project and generate good products so that followup will be well-received and hopefully the ship availability in AS will improve.

Fundamental point: In order to perform decadal investigation into biological variability, the consistent capture of data on regular sample grid is needed. CalCOFI given as an example of what is required. In the Indian Ocean, even in the Arabian Sea, such a regularly obtained set of data is not available.

Landry: "For all we know, changes to AS fishery stocks are already underway."

Q3: Are resources already over exploited? Climate impacts on fishery migration routes?

Fish aggregation devices (FADs) account for 70% of purse seine catch in western IO. Tuna caught at FADs are under stress (smaller individuals relative to those in free schools). Turn this around as an ecological manipulation experiment to test trophic cascade potential. Are plankton community structure, trophic interaction and biogeochemical cycles impacted by concentration of tuna in FAD regions? NOTE: Paper by Hallier and Gaertnes (2008) (MEPS 353).

Hermes: Interesting trophic link of interest/concern to fishery scientists. Match and mismatch whereby phytoplankton bloom appears in areas where larvae are not yet in place, or phytoplankton bloom appears prior to spawn. NOTE: Paper by Cushing.

Cushing, DH (1990) *Plankton production and year-class strength in fish populations: an update of the match/mismatch hypothesis in Advances in Marine Biology* (eds) JHS Blaxter and AJ Southward. Academic Press Limited, San Diego, CA. pgs: 250–313.

National Perspectives and Program Overviews

SIBER India: Projects, progress and plans

Wajih Naqvi

An update of the SIBER India program that is sponsored by the Ministry of Earth Sciences (MoES) was presented. Under this program fourteen projects have already been approved and initiated. Six of these projects fall under the open ocean cluster whereas eight others belong to the estuaries and coasts cluster. Under the latter group, observations are being made in estuarine/coastal waters along/off Goa, Cochin, Parangipettai and in the Sundarbans. The observations in the coastal regions are proceeding as planned. For example, monthly/fortnightly data have been collected in the Mandovi-Zuari estuarine system of Goa and along a coastal transect for 1 year and in the Vellar–Coleroon estuarine system for 2 months. However, there are problems in operation/maintenance of the two open ocean time series sites, one each in the Arabian Sea and the Bay of Bengal. The Arabian Sea site could be visited only once (in September 2010) whereas the Bay of Bengal site was visited twice (in February and May 2011). Sediment trap moorings have been deployed at both locations. There are two major constraints. First, the MoES research ships are overcommitted, and so sufficient ship time is not available for SIBER projects. Secondly, in the case of the Arabian Sea, piracy is another major issue. In fact, on two occasions we could not visit the time series site because of safety concerns even when a research vessel was available. Efforts are being made to address these issues.

Discussion Points:

Naqvi: Arabian Sea time series cruises are problematic for obtaining ship time from MoES vessel allocation. MoES plans to charter ships in order to meet its cruise obligations.

SIBER-relevant research off of Western Australia

Lynnath Beckley

An update of research projects relating to SIBER being conducted off Western Australia was presented. The results of an extensive cruise of the Leeuwin Current from 34-22°S conducted in May 2007 are currently being published. Attention was drawn to the paper by Thompson *et al.* (2011) on nutrients in this oligotrophic boundary current, which has revealed narrow interleaving layers of low dissolved oxygen and higher nitrate at the northern stations, which may fuel the phytoplankton bloom further south in the Leeuwin current. The origin of these layers requires examination but may be associated with N_2 fixation. Larval fish distributions were also examined and some particle back-tracking using the Bluelink product BRAN has helped confirm origin of larvae of coastal fishes found out in oceanic waters.

A study of the biological oceanography of the western rock lobster commenced in 2010 in response to the remarkable decline in recruitment experienced in the past five years. The focus was on evaluating the pelagic environment of the planktonic phyllosoma stage

of the rock lobster and an extensive area from 28-32°S and out to 111°E was surveyed. Attention is being given to ascertaining the trophic relationships of the phyllosoma larvae using isotope, genetic and fatty acid analyses. Experiments were also conducted in aquaria aboard ship to examine feeding preferences. In 2010 the first extensive biological oceanography cruise to the remote Kimberley region of northern Australia was also conducted. This ria coast experiences very large tides and considerable fluvial discharge during the summer and is under considerable pressure for development of oil and gas resources. Sampling for physics, chemistry, phytoplankton and zooplankton took place along five cross-shelf lines and the first preliminary publications have appeared (Thompson & Bonham 2011 and Holliday *et al.* 2001).

Reference was also made to new opportunities for biological oceanography and biogeochemistry research in Australia, particularly through IMOS, the new RV Investigator and Bluelink modeling.

Update on the Western Australia node of IMOS

Tim Moltmann

Australia's Integrated Marine Observing System (IMOS) is a fully-integrated, national system observing at ocean-basin and regional scales, and covering physical, chemical and biological variables. IMOS operates ten different Facilities that deploy equipment and deliver data streams for use by the entire Australian marine and climate science community and its international collaborators. Both the IMOS Bluewater and Climate Node and Western Australian Regional Node are relevant to SIBER, addressing science questions about Boundary Currents (especially factors influencing the Leeuwin Current variability), Continental shelf processes and Biological responses. IMOS has deployed mooring arrays (deepwater and shelf), ocean gliders, coastal radars, animal tracking and monitoring systems, autonomous underwater vehicles and ship of opportunity lines (including XBT and CPR) in the SIBER region of interest.

This presentation highlighted how IMOS infrastructure captured recent surface warming after the peak of the 2010/2011 La Nina, new moorings to monitor the Indonesian Throughflow which have already shown significant freshening due to the 2010/2011 La Nina, new infrastructure on the continental shelf of north west Western Australia, a planned process study to be carried out in conjunction with the US Naval Research Laboratory (NRL) on the Northwest Australian shelf, and a proposed vessel-based process study on eastward jets in the southern Indian Ocean in the area of the proposed 25S RAMA mooring site.

Discussion Points:

Moltmann: Blue water node of IMOS should have stronger intrinsic links to broader SIBER interests than the shelf assets. Recommends a proactive approach to establishing data portal that SIBER employs to serve new observations (and data mined obs)

D'Adamo: Bluelink going to global 10 x 10 km. Several other efforts are underway for developing IO basin models. Model intercomparison efforts are on the way.

Cowie: Real opportunity to include W. Australia margin (benthos and pelagic studies). Should consider this as a focal point for SIBER activities. Push this as a Hot Topic (i.e., Theme 4 addendum)?

Hood: Is there an opportunity to establish an Australian National Project Office for SIBER? Can this be accomplished (question put to Beckley, D'Adamo, Moltmann, Meyers)? Could IMOS identify an individual to take on executive director responsibilities?

Moltmann: Need to define what an Australian National program office would entail. IMOS is funded through national as well as state funding.

Meyers: First small step to submit proposal to IMOS office is a good idea. Australia has been an important player in international programs. But not aware of such similar national program office for these other efforts. So, questions what will this office's function be since there are Australian researchers already on board.

Hood: A primary interest is to raise awareness for attracting other Australian labs/institutions to the SIBER activities.

Action Item: Develop a proposal (iterate w/ Moltmann) to submit to IMOS. Goal is establishment of an Australian National Project Office for SIBER.

Update on SIBER-relevant activities in Indonesia and eastern rim nations and potential linkages to SIBER

Dwi Susanto and Zainal Arifin

The Indonesian Throughflow (ITF) is the seepage of western Pacific water into the Indian Ocean through the Indonesian Seas. The ITF has an annual average net volume transport estimated to be 15 Sv. This Indo-Pacific connectivity has long been recognized as a key component of the global climate system. Even though there have been more than two decades of ITF field measurements (at different times and within different straits), and the Throughflow region encompasses the Coral Triangle and is a demonstrated hot spot of marine biodiversity, there have been no estimates of the biogeochemical fluxes associated with the ITF.

The longest monitoring campaign in the ITF is within the Makassar Strait, a collaborative research effort between USA (supported by NSF and subsequently NOAA) and Indonesia from 2003 to 2011. There is an on-going filed program called SITE (South China Sea- Indonesian Seas Transport/Exchange), which is a multinational collaborative research between Indonesia, China and USA to measure the ITF branch through South China Sea. In addition, there is a field measurement effort in the Sunda Strait in collaboration with Chinese and Indonesian scientists, which will end in 2012. Unfortunately, due to strong currents within the thermocline that affect mooring safety, biogeochemical sensors have not been deployed on the ITF moorings. However, during mooring recovery and redeployment cruises, CTD casts that include measurement of nitrogen, oxygen saturation and chlorophyll etc. have been performed, which may provide first order estimates of biogeochemical fluxes associated with the ITF.

Given a direct linkage between Indonesian waters and SIBER interests, geographically and dynamically, we should strongly advocate integrated physical and biogeochemical measurements at least in the major ITF inflow and outflow passages. Indonesian research agencies, such as Indonesian Science Institute (*LIPI*) and the Research and Development Agency for Marine and Fisheries (*Balitbang KP*), as well as the Agency for Assessment and Application of Technology (*BPPT*) have been involved in obtaining ITF measurements. Even though all three agencies actively engage in ocean observations, most of their biogeochemical research is conducted in localized regions where determination of sampling domain is driven by local economics and environmental problems. Hence, SIBER should promote and seek a possibility to have an international collaboration on the ITF and its impact on biogeochemical fluxes and ecosystem in the Indian Ocean.

One likely organization for establishing an international collaboration, due to close alignment with SIBER goals, is Arafura and Timor Sea Ecosystem Action (ATSEA; www.atsea-program.org). Over the 2010-2014 time frame, ATSEA is supported by UNDP-GEF (United Nations Development Programme – Global Envorinment Facility) and executed by UNOPS (United Nations Office for Project Services).

Discussion Points:

Hood: Suggest to follow up Gary's suggestion of using a T:NO3 relation to estimate nutrient input to ITF as a first order product.

Wiggert: If runoff is a considerable component of surface nutrients in waters from Indonesian archipelago that enter ITF, this T:NO3 relation method may have inherent challenges.

Promoting SIBER in Indonesia and other NE IO rim countries.

Hermes: If requested, BOBLME could try to facilitate approval for Indian research vessels to work within the NE EEZ.

Susanto: Desires to bring additional Indonesian representative on to SSC.

Hood: Monetary constraints. Also competing interests, priorities to address (e.g., China rep). IRF may provide further funding that would facilitate expanding the SSC membership.

SIBER-relevant activities in the Maldives and potential linkages to SIBER

Shiham Adam

A Proposal to Investigate:

Monsoon Forcing, Biogeochemical Response and Pelagic Ecology Around Indian Ocean Islands

Introduction: In the tropical Indian Ocean, oceanography and pelagic ecology of are dominated by the monsoons. A more general phenomenon is the interaction of oceanic islands with the flow of the ocean currents to produce enhanced productivity: the so-called island mass effect.

The interaction of monsoon currents with oceanic islands within the tropical Indian Ocean promotes marked seasonal responses in nutrient availability, plankton abundance and the distribution of top predators. However, such interactions have been very poorly studied in this region. For example, little is known about the factors controlling phytoplankton production, the significance of any mesopelagic boundary community, the importance of major tuna fisheries in modifying food webs, or the potential impacts of climate change.

In the tropical Indian Ocean, the Maldives appears to be an ideal site for the study of these processes, for several reasons.

- The Maldives atoll chain runs north-south, perpendicular to the east-west flow of monsoon currents, as a result of which the effects of physical forcing are especially strongly expressed

- The Maldives is in the heart of the monsoon region, and the seasonal oscillations of the monsoon currents provide a natural experiment, with twice yearly changes in prevailing conditions

- The Maldives is composed entirely of atolls, with no high island at all, as a result of which there is minimal terrestrial run-off, so the dynamics of the system should be 'relatively' simple

- The Maldives has a superb time-series of tuna catch and effort data (plus other data on the seasonality of cetaceans and mantas) which should allow modelling and analysis of top-down influences on food webs.

Proposal: It is proposed to carry out a small research activity to investigate seasonal monsoon forcing, biogeochemical response and their impact on pelagic ecology in the region of the Maldives archipelago. This would be a pilot activity, which could be extended in the Maldives (e.g., to provide a better understanding of anthropogenic impacts) or expanded to other areas.

The proposed pilot study would have the following components:

- Desktop: compilation and analysis of available ocean colour (e.g. SeaWiFs, MODIS) and top predator (e.g. tunas, cetaceans) data.

- At sea: two research cruises (in the SW monsoon e.g., August, and the NE monsoon e.g., February). On each, conduct transect across Maldives (eg along 4°N) to sample oceanographic parameters (including nutrients), phytoplankton, zooplankton and micronekton.

- Synthesis and reporting

Relevance to SIBER Themes

This activity would address the following SIBER Themes and core questions:

Theme 4. Controls on, and fates of, phytoplankton production in the Indian Ocean.

1. How do phytoplankton production and its controlling factors vary across the Indian Ocean and with season?

Theme 5. Climate and anthropogenic impacts on the Indian Ocean

1. How are warming and acidification influencing biogeochemical cycles and ecosystem dynamics in the Indian Ocean and how will their impacts propagate in the future?

Theme 6. The role of higher trophic levels in ecological processes and biogeochemical cycles

1. At lower levels of the food web, where small consumers interact most intimately with primary producers and biogeochemical cycling, what are their roles in regulating the composition and structure of planktonic communities and the magnitudes and directions of carbon and nutrient fluxes?

2. At intermediate and higher trophic levels, what are the dynamics, impacts and vulnerabilities of dominant stocks/populations like myctophids, and how do their biomass variations affect lower trophic levels and vice versa?

3. At the top of the trophic hierarchy, what are the climate and human (fisheries) influences on major predator stocks (such as tuna) that could exert top-down pressures on the functioning of food webs?

Linkages to Current Sampling Activities

Livebait: Maldives has long tradition of livebait pole-and-line tuna fishing dating back hundreds of years. A prerequisite for pole-and-line tuna fishing is the availability of livebait used to attract and maintain the tuna school within reach of the fishing vessel. Of the dozen or so species used for livebait, the most important two are planktivores: Blue and Silver Sprat (Spratelloides gracilis, and S. delicatulus respectively), Fam: Clupeidae.

Current catches of livebait are of the order of 20,000 t annually and these two species contribute close 45% of the total livebait catch. Recently fishermen have been complaining about the lack of livebait. Lack of bait may also have contributed to recent declines in tuna catches.

As part of a larger environmental capacity building project, supported by the WB/GEF, Maldives is strengthening the capacity to manage the livebait resources. One area that lacks information is its ecology, in particular its distribution and abundance of livebait species. Because they are planktivores improved understanding of the primary productivity will be important and will complement work being done in the Maldives.

Tuna Fishery: Catches of skipjack tuna (Katsuwonus pelamis) in the Maldives rose a peak of 120,000 t in 2006 but since then has been declining. Recorded catches in 2009 were almost 40% lower than 2006. While local over-exploitation may not be ruled out it is also believed environmental factors play a crucial role in their distribution and abundance. Studies of primary productivity around the Maldives will provide extra dimension of information in explaining the seasonal and regional variation of skipjack abundance, but also of their declining trend.

Charismatic Mega-Fauna: Whale sharks and manta rays have now become important species in the tourism industry. A substantial amount of money is spent by the tourists on whale shark watching and manta-ray watching. There are a number of research activities on whale shark and manta rays in the Maldives and understanding of primary productivity will complement these activities.

Coral Reefs: Coral reefs are under significant stress from anthropogenic and climate related impacts. On the climate front they are subjected to thermal stress, rising acidity and from the combined impacts of warming and acidification. Unfortunately there is no research being done in the Maldives on the climate effects to coral reefs. As a complement to the current coral reef monitoring activities in the Maldives it is proposed to have a carbonate system (pH) monitoring array across the Maldives to study the acidification issues and its impacts to coral reefs.

Discussion Points:

Hood: What are the funding mechanisms for Maldives research? An international entity is needed to identify/obtain support. Maldives are in BOBLME domain. How would UNESCO potentially be tapped for supporting research?

Hermes: Linking to secondary production would be a good hook for funding (but would require resources other than BOBLME).

Naqvi: Could submit proposal to India (Ministry of Foreign Affairs). That could lead to shiptime support as well.

Update on SIBER-relevant activities in Oman and the Arabian Sea

Adnan Al-Azri

The extensive coastline of the Sultanate of Oman has shaped its culture, economy, history and its people for millennia. Today, even with an oil-driven economy, coastal marine resources are still of great economic importance and continue to influence and sustain the lifestyle of the people of Oman. Marine living resources along the coast of Oman provide abundant food and opportunities for tourism and recreation. Unfortunately, the continuous pressure of development threatens this marine environment primarily via over-fishing, global climate change, habitat modification and destruction and coastal zone pollution. One of the clear indications on the changes happening in the coastal water of Oman is the frequent occurrence of the harmful algal blooms.

The Arabian Sea and Sea of Oman experienced devastating Harmful Algal Blooms (HABs) in 2008 that caused massive kills of marine organisms and had significant economic impacts on desalination plants and tourism. Over the past 10 years these outbreaks have been on the rise and the forces contributing to more frequent blooms are still unclear (Fig. 1). One of the limitations has been the lack of a dedicated monitoring program, and a systematic multivariate sampling strategy along the coast and offshore waters at regular time intervals. As a consequence, the region is poorly investigated in terms of seasonal and inter-annual variability of phytoplankton communities, and their related driving forces. We have been collecting data from monitoring sites in the coastal areas that will not only provide us with baseline data necessary for future studies on

anthropogenic impacts on this ecosystem but also a better understanding of the seasonal and interannual changes associated with monsoonal forcing. In this paper we address the seasonal monsoonal cycle and its impact on the biology of the coastal waters and use our findings to arrive at conclusions about how variability in phytoplankton and its environment could impact the food chain of this ecosystem.

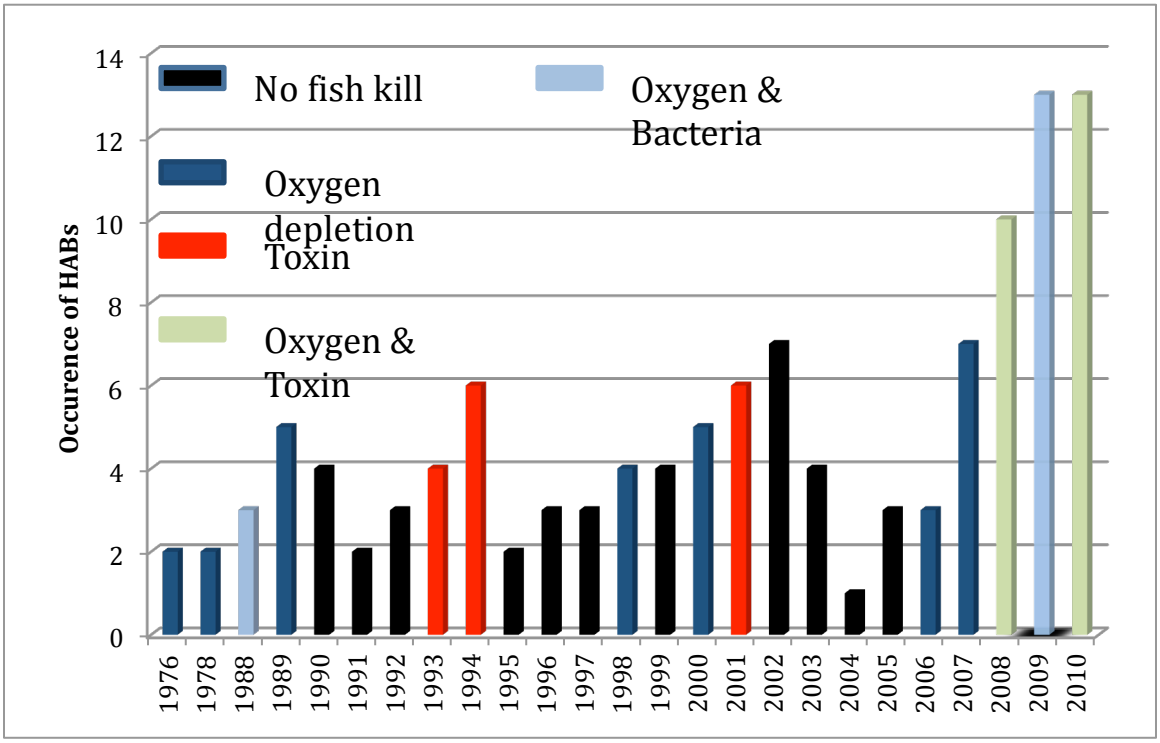

Figure 1. Occurrence of HABs in Omani waters. Modified from Ministry of Agriculture & Fisheries reports.

Discussion Points:

Al-Azri: Qatar University: New research vessel. 42.8 meter ship. They have a need to keep ship busy, so this is an opportunity for Oman researchers to take advantage. Establishment of a National Oceanographic Data Center. There is a general need for better coordination of research efforts within Oman, as well as between the regional states.

Naqvi: SIBER should work to promote regional cooperation. Develop bilateral or multi-lateral agreements.

Al-Azri: Has recently invested in equipment that may be appealing for visiting scientists to come to SQU and collaborate with Omani scientists.

Al-Azri: HABs were extreme, shutting down refineries, de-salinization plant, hotels (tourism). Mechanism of generating HABs is really unclear.

Cowie: Sardine kill along coastal California. Avoidance of HAB, aggregate in small water volume that then leads to O2 depletion and suffocation.

Update on German research in the Indian Ocean

Tim Rixen

During the last SIBER meeting in Perth 2010 two SIBER-related project proposals were introduced. One was an application for ship-time in order to study the nitrogen cycle in the Arabian Sea with the German RV Meteor. The second proposal was a contribution to the initiative "Monsoon Dynamics in Central Asia" of the German Federal Ministry of Education and Research (BMBF). The research cruise proposal was finally rejected because of piracy and the seconded proposal was funded. It is called CARIMA and aims at the investigation of natural versus anthropogenic controls of past monsoon variability in Central Asia recorded in marine archives. One of the two CARIMA work pages will use Arabian Sea sediments as a monitor of the Asian monsoon system and is strongly related to SIBER. Furthermore the possibility to raise EU-funds was explored. The EU focuses mainly the oceans surrounding Europe but in principle there is also an interest in international co-operations out side Europe and the development of new techniques, which might provide a long-term perspective for SIBER.

Sediment cores obtained off Makran coast (700 m water depth). Turbidite layer through 1911. Then 6800 years of annual layers. This evidence is used to establish modification of monsoon over time. Show significant episodes of lithogenic layers as well, indicative of major runoff events.

Discussion Points:

Rixen: N-cycle cruise originally approved for Arabian Sea was cancelled completely due to piracy.

Rixen: WAST mooring has been deployed for 3 years.

Hermes: Suggests that German Navy that is deployed in Arabian Sea could be tapped for extracting the mooring.

Update on current research plans for the Indian Ocean by JAMSTEC

H. Kitazato

Current activities and planning cruises by JAMSTEC since FY2010

Physical oceanography and modeling: Active work has been continuing by RIGC scientists over all areas of the Indian Ocean

Buoy and hydrography: R/V Mirai cruises for both buoy maintenance and hydrography will be held on 2012 and 2013.

Hydrothermal vent ecology: "Yokosuka-Shinkai 6500" cruise was held in 2009 and will be scheduled in 2013 in southern Indian Ocean (Rhodrigez Ridge Area. Motivation of

the cruise is to examine the diversity of Indian deep-sea hydrothermal Geo- and Bio-systems.

OMZ biology & biogeochemistry: Shinkai 6500 cruise was held on 2008. We had a related session at 2011 EGU meeting and plan to edit special issue in Biogeosciences. HOV or ROV dive cruise at OMZ will be planned sometime during 2014~2015.

Other topics: Several small research plans are running by scientists who are belonging to JAMSTEC and several different universities. (e.g., mid water ecosystem research using PICASSO (Fig. 2), in collaboration to CSIRO).

Figure 2. Plankton Investigatory Collaborating Autonomous Survey System Operon (PICASSO). Outfitted with high vision camera, plankton recorder, CTD and sensors.

Benthic process studies in the Indian Ocean: Where do we go from here?

Greg Cowie

Firstly, a summary was presented of the key benthic research questions and recommended scientific approaches that were first identified at the original SIBER workshop (Goa, 2008) and subsequently incorporated into different themes within the SIBER science plan. This was followed by an update on recent benthic process studies in the Indian Ocean, including UK-India studies on the western Indian continental shelf

(Cowie/Naqvi) and a Dutch cruise project on the Murray Ridge (NE Arabian Sea, Reichart et al).

The presentation was completed with a summary of geochemical studies of sediments from sites spanning the Oxygen Minimum Zones (OMZs) on the Oman, Pakistan (Indus) and Indian (Goa) margins of the Arabian Sea. Organic matter (OM) distributions showed maxima within or at the lower boundary of the mid-slope OMZs, and stable isotopic and biomarker compositions clearly illustrated overwhelming predominance of marine vs terrestrial inputs, on all three margins. However, both the Oman and Indian transects showed marked variability in OM content and degradation state within the OMZ, clearly indicating that oxygen is not the only factor controlling OM distribution. Sediment grain size analyses revealed that OM content on all three margins was strongly related to silt content. This, combined with pollen distributions, was used to infer that strongly differing hydrodynamic regimes are responsible for observed contrasts in OM distribution across the OMZs on three margins. Thus, while long-term exposure to O_2 below, and possibly above, the OMZ causes low sedimentary OM content, variability within the OMZ is determined predominantly by hydrodynamic sorting and distribution of intact (marine) organic debris.

Science Talks Given by Invited Experts During SIBER-2

New production in the Indian Ocean

R. Ramesh

Research in the Bay of Bengal

P. N. Vinayachandran

Discussion Points:

Hermes: Suggest promotion of collaboration with Bay of Bengal rim countries not yet engaged in IOGOOS and SIBER (e.g., Bangladesh, Myanmar).

Naqvi: Perhaps India (under SIBER banner) can provide ship that would promote a sampling program in the eastern Bay of Bengal where there is really a dearth of data.

SSC Collaborative efforts: Potentially leverage current research that SIBER SSC members (and external colleagues) are leading and evolve toward a journal special issue that is a clear deliverable from SIBER.

The Indian GEOTRACES Program

S. Singh

Discussion Points:

One objective of GEOTRACES is to quantify micronutrient inputs associated with ground water discharge.

Focus on interfaces (i.e., inputs such as crust, atmospheric deposition etc.) and internal cycling

TEIs (trace element interaction) in Arabian Sea, Bay of Bengal and other regions of the Indian Ocean

Major funding provided by MoES to obtain clean sampling system
Gi04 Cruise Line (Japan, completed 2010).
Gi01-GI03 Lines (India, planned cruises. AS line will be dependent on piracy influence).

Presentations from Joint SIBER-IOP Session

Efforts to deploy biogeochemical sensors in the Indian Ocean: Progress since SIBER-1

Raleigh Hood

The overarching objectives that provide the motivation for deployment of biogeochemical sensors on RAMA moorings in the Indian Ocean are: 1) To provide data for defining biogeochemical variability in key regions of the Indian Ocean and for understanding the physical, biological and chemical processes that govern it; 2) To provide data for developing and validating models of ocean-atmosphere-biosphere interactions; and 3) To provide baseline data for assessing the impacts of climate change on oceanic primary productivity, air-sea CO_2 exchange and acidification.

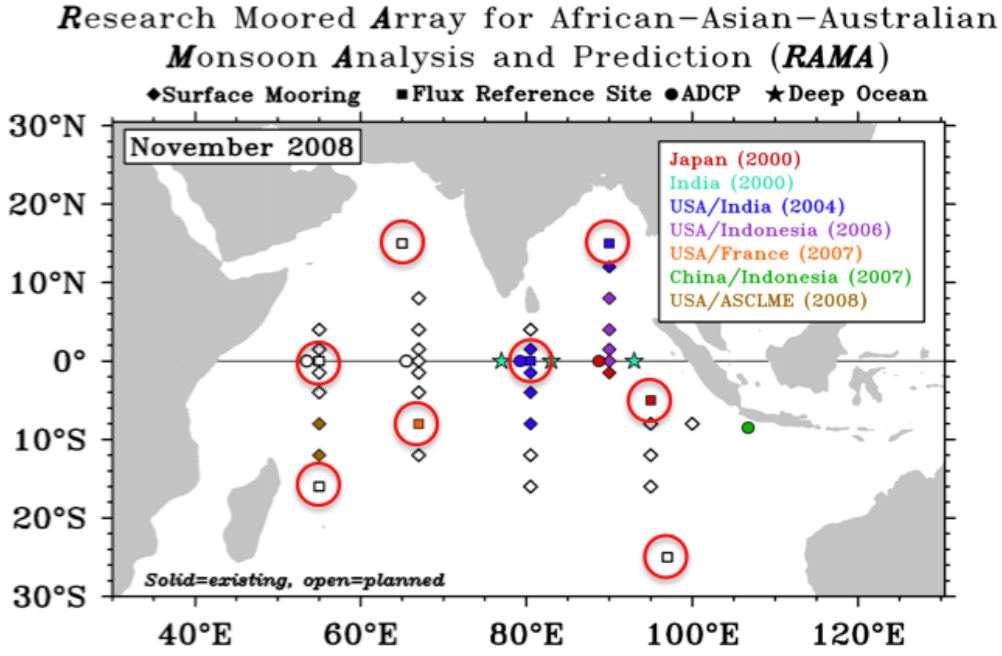

Figure 3: Proposed RAMA mooring locations with the Flux Reference Sites (circled in red) targeted for biogeochemical sensor deployment.

The RAMA (Research Moored Array for African–Asian–Australian Monsoon Analysis and Prediction) mooring array design/deployment team has identified 8 sites for air-sea observatories (Flux Reference Sites, Fig. 3). These sites are also logical places for deployment of biogeochemical sensors. SeaWiFs chlorophyll monthly climatologies (not shown) reveal that the 4 western sites are of general interest due to their high biological variability. In contrast, the eastern sites have much lower variability but should experience short-term pulses of physical and biological variability that are not revealed by coarse resolution climatologies. One interesting aspect of the 26S 97E mooring in the southeastern Indian Ocean is that numerous eddies come off the Leeuwin Current and the mooring would be situated to capture the biogeochemical impact of these.

The order of scientific priority for deployment pairs are: 1) The RAMA flux reference sites in the Arabian Sea and the Bay of Bengal due to the profound differences in biogeochemistry that result from small differences in oxygen with physical control involved (*However, the Arabian Sea may be out due to piracy problems);* 2) The RAMA western equatorial site (0S, 55E) and the site off of SW Indonesia in the eastern equatorial Pacific (5S 95E), which is ideal for studying across equatorial and IOD impacts in the Indian Ocean (*However*, *the western equatorial site may be out as well due to Piracy;* 3) The RAMA SCTR site (8S, 67E) and the equatorial site south of Sri Lanka (0S, 80E), where the latter provides a potential control for studying the anomalous shallow chlorophyll maximum and biogeochemistry of the SCTR; and 4) The RAMA southern Indian Ocean Madagascar/Mauritius basin site (in the west, 16S, 55E) and the Leeuwin Current eddy-influenced region (RAMA flux reference site at 26S 97E in the east), where the former has monsoonal influence and higher production whereas the latter is highly oligotrophic but strongly influenced by eddies.

In terms of sensors, CO_2 and pH are the highest priority given relevance to the global carbon cycle (NOAA has expressed interest in deploying CO_2 sensors on RAMA moorings in the Indian Ocean, Chris Sabine and Mike McPhaden, personal communication). These measurements would fully constrain the carbon system and allow assessment of ocean acidification. The next highest priority would be biological sensors, i.e., fluorescence and backscatter for determining chlorophyll and POC, which can reveal biological responses to physical forcing. Finally, having oxygen would be excellent for comparison with CO_2 and the biological measurements. It is entirely feasible and highly desirable to deploy oxygen sensors on the RAMA moorings. Combined they can provide information about primary production rate and net community metabolism.

One of these sensors packages was deployed at the EQ, 80E mooring on 22 May 2010 as an unfunded pilot program to demonstrate feasibility. The EQ, 80E site was selected for logistical reasons, i.e., this buoy was being serviced and therefore made deployment of the sensors possible in a timely manner. Funding for the purchase of additional BGC sensors will be provided by the Bay of Bengal Large Marine Ecosystem project for deployment in the Bay of Bengal. Deployment, recovery and servicing will by provided by NOAA/RAMA. A letter of agreement is being drafted.

The SIBER SPIS proposes that these 8 locations be instrumented in a stepwise fashion over several years. A phased approach is proposed: Install biogeochemical sensors in the Bay of Bengal and Arabian Sea by the end of 2012. Install all eight stations by 2017. This is ambitious, but consistent with OceanObs 2009 conference statement that called on all nations and governments to complete GOOS by 2015. We believe that 2017 is, perhaps, more realistic for biogeochemical sensor deployment. The BOBLME program will provide funding for deployment of the first biogeochemical sensor package on the RAMA Flux Reference Site in the Bay of Bengal.

Complete deployment of the proposed mooring pair in the Bay of Bengal and the Arabian Sea will require an additional $276,000 USD in 2012. But questions remain as to whether or not we can deploy in the Arabian Sea due to the piracy problems. To achieve the long-term goal of basin-wide BGC sensor deployment at all 8 locations, considerable additional resources are needed (~$2.0 million or $400,000 USD per year) over the next 5 years. But these costs need to be revisited and may have dropped. A request has been submitted to the IRF to help find these resources.

Status of IndOOS and RAMA

Gary Meyers

The Indian Ocean Observing System (**IndOOS**) is a regional contribution to the Global Ocean Observing System (**GOOS**, http://www.ioc-goos.org/). IndOOS was planned by the CLIVAR/GOOS Indian Ocean Panel (http://www.clivar.org/organization/indian) and is being implemented by the IndOOS Resource Forum (**IRF**). IndOOS addresses the need to establish a system for comprehensive, long-term, high-quality, real-time measurements in the Indian Ocean suitable for climate research and forecasting, which provide scientific basis for socio-economic applications such as agricultural, fishery, and water resources managements (Fig. 4). It also provides data on ecosystems and living resources in the Indian Ocean and how they depend on the physical environment. IndOOS uses a variety of instruments (Fig. 5) that can be maintained at sea for extended periods, and that can be operated in a cost effective way. Importantly the components of IndOOS provide data via satellites in real time or near real time.

The rapid changes that can occur in the Indian Ocean dictate the need for a moored buoy array providing continuous time series data with high temporal resolution as an essential element of IndOOS. In this respect, RAMA supports research, understanding and predicting the East African, Asian, and Australian monsoons. In addition, real-time RAMA data contribute to improved weather and marine forecasts, such as those for tropical cyclones and storm surge. In July 2011, 30 of the 46 sites had been occupied and new sites are being added each year.

Figure 4: Schematic of ocean observing system in the Indian Ocean and its values for socio-economic applications. Data obtained by the observing system with various instruments are delivered to users directly or indirectly through weather/climate/ocean forecasting

The XBT lines are the oldest component of IndOOS and are particularly valuable for assessment of change in thermal structure of the Indian Ocean over multi-decadal time scales. The first lines were started in 1983. At present XBT sampling is carried out on seven lines in the tropical and subtropical areas of the Indian Ocean. Typically, each line is covered 12 to 18 times per year.

Drifting buoys at the sea surface and Argo floats at depth have been implemented in the Indian Ocean in accordance with the international plan for GOOS as administered by JCOMM. There are more than 3000 Argo floats in the global ocean at present, 760 of

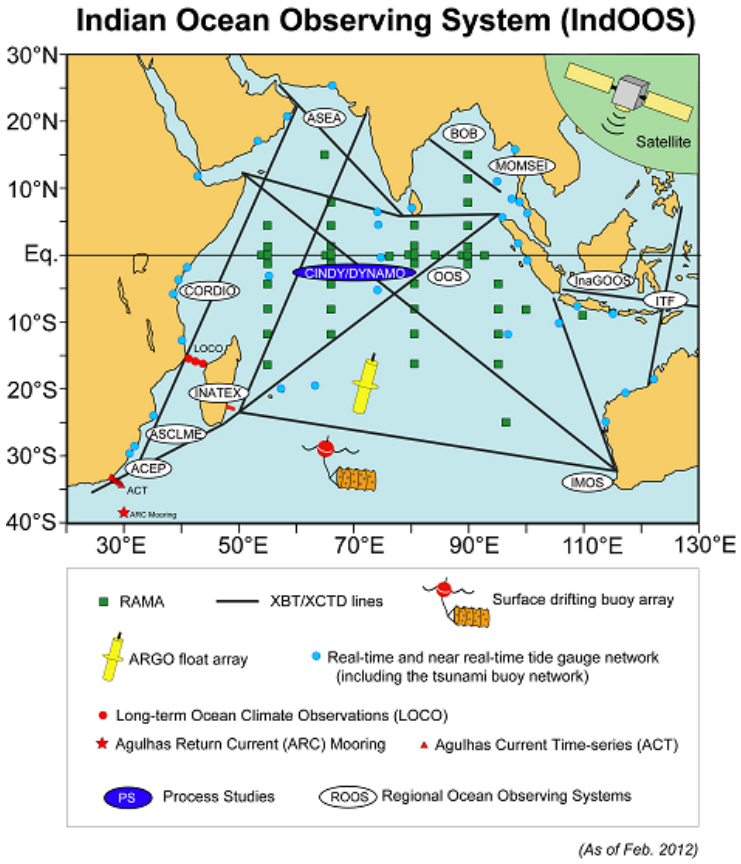

Figure 5: The Indian Ocean Observing System. These regular XBT/XCTD lines date from 1983 and are the oldest component of IndOOS. Green dots are fixed mooring sites in the RAMA array. The first moorings were deployed in 2000 by agencies in Japan (JAMSTEC) and India (NIO). Argo floats are robotic instruments that measure temperature, salinity and biological properties to a depth of 2000 m. Surface drifting buoys measure temperature and current. Tide gauges measure sea level and the real-time reports monitor tsunamis. There are several Regional Observing Systems around the Indian Ocean that collect data in coastal regions.

these are in the Indian Ocean sector. The floats observe nearly all of the thermohaline structure of the Indian Ocean with scales larger than 300 km and shallower than 2000 m. Despite recognition of Argo's success and broad uptake, little new resources are available to sustain Argo in the long term. Enhancement of floats to measure biogeochemical properties is often suggested; however, Argo cannot QC new data streams without new resources. New float communities (e.g. bio-Argo) are encouraged to define data standards and QC protocols for new parameters, and to obtain resources for their application.

In addition to in situ measurements, satellite measurements of ocean surface conditions and variables in the atmosphere are an important backbone of IndOOS, providing high resolution spatial information for climate research and various applications. Close cooperation between the in situ ocean observing system and satellite observations must be strengthened to further advance our understanding on climate variations in the global domain.

Today, while IndOOS/RAMA is growing, we are facing some issues. One is lack of resources, in particular the ship-time for deploying and recovering the moored buoys and Argo floats. Coordination and collaboration under IRF is a key to maximize our limited resources and to obtain continuous data from the Indian Ocean. Another issue is piracy in the northwestern Indian Ocean, which prevents any research cruises and observations in recent years. Strong leadership and international collaboration will be required for full implementation of IndOOS and for providing continuous data from the Indian Ocean that has large socio-economic and academic benefits.

India's mooring, Argo float and biogeochemical sensor deployments

M. Ravichandran

An update on the India's mooring time series, Argo profiling floats and deployment opportunity of biogeochemical sensors in the Indian Ocean was presented. He reported that there are 15 moored buoys similar to RAMA were deployed by India in the North Indian Ocean. Only physical variables are being measured from all the moorings. He also mentioned that one Bay of Bengal sub-surface moorings (89 E / 18.5 N) was deployed by INCOIS for measurement of high frequency (10 minutes interval) temperature, salinity and currents in the top 100 m of the water column. From 2012, INCOIS has a plan to incorporate biogeochemical sensors in the same mooring, so that at this location all the physical and biogeochemical variables will be measured. He also reported the present status of Argo floats in the Indian Ocean with oxygen and chlorophyll sensors. There are 13 floats with oxygen sensors and 1 float with chlorophyll and optical backscatter are active in the Indian Ocean. He reported the preliminary observations of temperature, salinity, oxygen, chlorophyll-a and backscatter at 700 nm from the float deployed in southeastern Arabian Sea. He requested the SIBER community to utilize the data available in the Indian Ocean, especially oxygen sensors and demonstrate the value of the oxygen sensors in the Indian Ocean. This will facilitate deployment of more oxygen sensors in the Indian Ocean. He also mentioned that four Argo floats with ECO FLBBCD-AP2 and one float with Nitrate sensors will be deployed in the North Indian Ocean in the coming months.

Discussion Points:

Ravichandran: Indian moorings (15) in the Northern Indian Ocean. Sensor packages have a similar complement as those deployed on RAMA. Different choices for temp/salinity sensor depths. All 15 moorings have surface flux packages.

Naqvi: At 18°N, 88°E a sediment trap mooring (Naqvi) will also be deploying pCO2 sensor.

Ravichandran: Bio-Argo (T, S, DO, Chl, optical backscatter at 700 nm). Irridium communication is necessary due to data volume. Requests suggestions for location of Bio-Argo float deployment in Bay of Bengal (with dissolved oxygen, backscatter, chlorophyll, nutrients measurement capability).

Naqvi: Suggest that it be deployed as part of the Bay of Bengal research mooring. That way nutrient observations from cruise can be used to give some QC of the Argo nutrient sensor.

Naqvi: DO and salinity sensors on Argo floats may experience drift. There are ways to treat/post-process to correct (if drift is present in the data).

Prakash: Investigated this and characterized that drift was not too significant. This is a potential issue that needs followup to clarify fidelity of the Argo biogeochemical data.

Wiggert: Gather information on the nitrate sensor that is deployed on Argo floats.

Wiggert: Have a task team to explore Argo float data (BGC) that have been collected to date. Explore sensor drift aspect. Also work up interesting story from available data. Need to promote use of these observations so that their continued funding is facilitated.

Hood: Identify other biogeochemical sensor observations that are occurring in Indian Ocean. Should/Can SIBER initiate an effort, as well, to develop a data repository or at least an accounting of sources.

JAMSTEC, NOAA and FIO progress on deployment of CO_2 and other biogeochemical sensors

Yukio Masumoto and Weidong Yu

There is a strong consensus among scientists that development of meaningful interdisciplinary collaborations is important and necessary. One of the major topics for such collaborations in the Indian Ocean aims at understanding how physical processes impact biogeochemical cycles and air-sea CO_2 exchange and carbon export. To obtain observed data relevant to the above issues, great effort has been made to expand RAMA buoys to include biogeochemical sensors. The first fluorometer to measure chlorophyll concentrations at 25 m depth on a mooring buoy at 0°, 80.5°E was installed on 22 May 2010 by Dr. Pete Strutton, Univ. Tasmania in collaboration with PMEL/NOAA. This was an unfunded project, which was carried out with the intent to jumpstart biogeochemical measurements on RAMA. After this pioneering attempt, FIO and JAMSTEC have been working to develop and integrate new CO_2 sensors into RAMA buoy systems. The first CO_2-flux buoy was deployed at 8°S, 100°E on Feb. 2011 by FIO through China-Indonesia collaboration. Preliminary data from the CO_2-flux buoy (Fig.6) demonstrate large potential for physical-biogeochemical collaboration using RAMA buoys for our better understanding of biogeochemical and physical variability in the Indian Ocean. A new CO_2 sensor that is specifically designed for m-TRITON buoys is currently being developed at JAMSTEC.

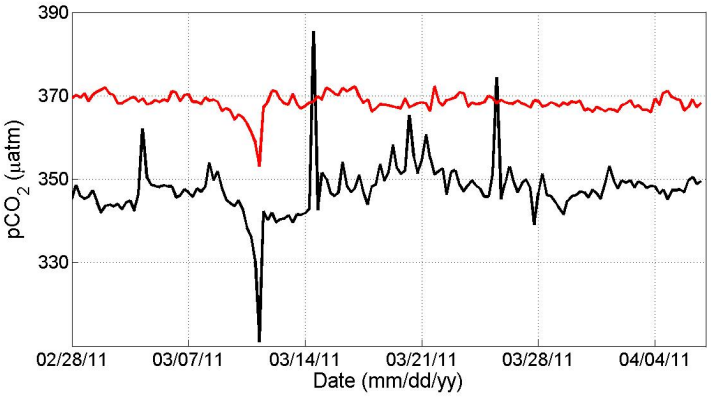

Figure 6: Time series of atmospheric (red line) and surface ocean (black line) pCO2 from the Bailong buoy deployed by FIO/SOA at 8°S, 100°E.

Since the biogeochemical sensors are developed independently at each institution, detailed information of the sensors, such as specifications, measuring method, data quality, accuracy, should be shared among relevant scientists. For this purpose, a workshop on biogeochemical sensors is discussed and planed likely in 2013.

The Bay of Bengal, BOBLME and potential linkages to IndOOS, RAMA and SIBER

Rudolf Hermes

The Bay of Bengal Large Marine Ecosystem (BOBLME, Fig. 7) Project is a five year (2009-2014), $31 million collaboration involving Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand. These eight countries are working together to develop a coordinated programme of action designed to improve the lives of the coastal populations through improved regional management of the Bay of Bengal environment and its fisheries (Fig. 7). The major implementation partners are the Fisheries and Environment Departments of each country. The BOBLME Project is funded principally by the Global Environment Facility (GEF), Norway, Sweden, the Food and Agriculture Organization of the United Nations (FAO), and the National Oceanic and Atmospheric Administration (NOAA) of the USA. FAO is the executing agency. The BOBLME Project has two major expected outputs. The first is a Transboundary Diagnostic Analysis (TDA), which identifies and ranks or prioritizes water-related environmental transboundary issues (over exploitation of fish stocks, habitat degradation, and land based pollution), and their causes, according to the severity of environmental and/or socio-economic impacts. It provides the scientific basis for the development of the Strategic Action Programme (SAP) that will formulate nationally and regionally coordinated activities to address the issues and their causes. The SAP is the prerequisite for a second phase of the Project, beyond 2014 and towards 2020, which will be tasked to implement the SAP. More information on the BOBLME Project can be found on www.boblme.org.

BOBLME follows the modular assessment approach for sustainable development, with indicators for five interconnected modules: fish and fisheries, productivity, pollution and ecosystem health, socio-economics and governance. Oceanographic variability, together with photosynthetic activity, zooplankton and ichthyoplankton biodiversity, and zooplankton biomass are the relevant indicators for the productivity module. Among a range of project objectives, dealing with fisheries resources management and habitat conservation, the objective of sub-component 3.1 aims to "*contribute to an improved understanding of large-scale oceanographic and ecological processes controlling BOBLME living resources*". In line with this objective, BOBLME has become an associate member of IOGOOS and formed Working Groups on oceanography, climate change and ecosystem health, promoting capacity building, adaptation to climate change, generation and exchange of oceanographic data and information, and ecosystem mapping and monitoring of indicators of ecosystem health.

SIBER, in its Science Plan and Implementation Strategy, has identified the need for deployment of biogeochemical sensors on RAMA Moorings, with the Bay of Bengal as a priority location. The SIBER objectives for deployment of biogeochemical sensors, e.g.to provide data for defining biogeochemical variability in key regions of the Indian Ocean (in this case, the BOB) and for understanding the physical, biological and chemical processes that govern it, are very much in line with the corresponding BOBLME objective. BOBLME is therefore prepared to contribute by providing a set of sensors for the BOB RAMA mooring (e.g. for CO_2, chlorophyll [fluorescence], oxygen, turbidity, and pH). Planning for purchase, deployment and retrieval needs to involve NOAA and Indian institutions (such as NIOT, INCOIS, NIO, and their research vessels) and has been

initiated. BOBLME wants to ensure that data collected as part of this activity will be freely available e.g. via the internet. Data access to regional scientists and related capacity development should be promoted under this collaborative effort.

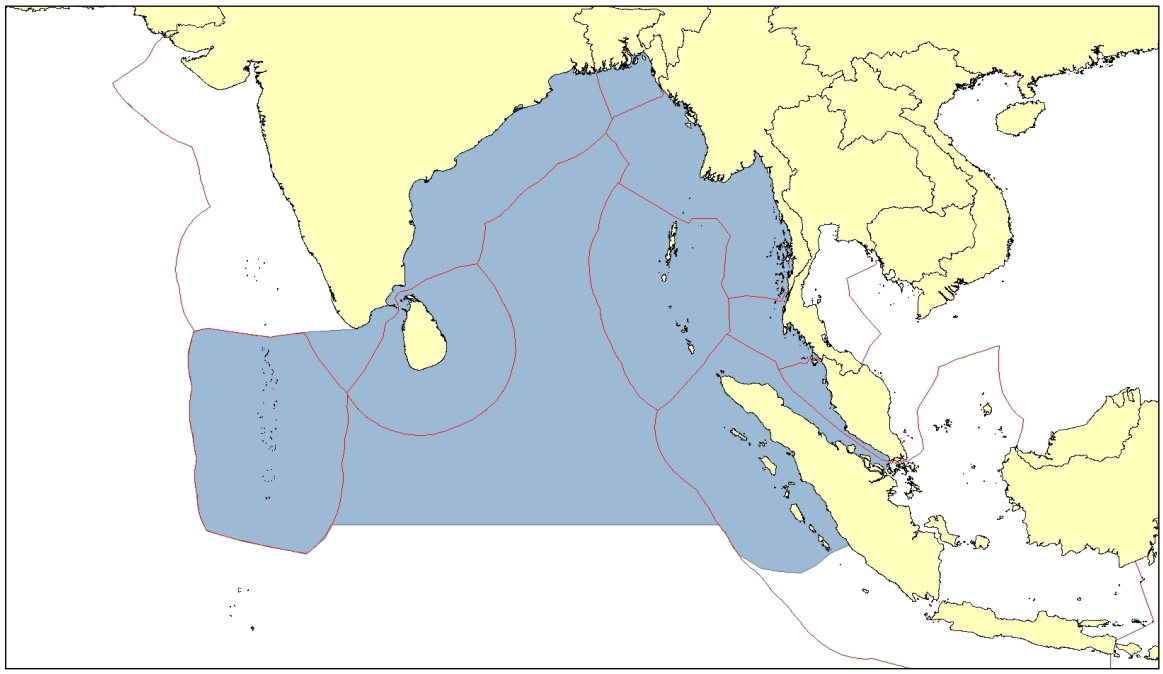

Figure 7: Map of the Bay of Bengal Large Marine Ecosystem indicating EEZ boundaries (source: SAUP Project, UBC)

Discussion Points:

BOBLME encompasses coastal regions of India, Sri Lanka, Bangladesh, Myanmar, Thailand and Indonesia. One of a subset of LME that have an international waters component. Many LMEs are coastal and solely within regional EEZ.

BOBLME Oceanography Working Group: Recommended, as part of capacity building activities, to provide support of SIBER biogeochemical sensors on RAMA mooring

BOBLME Project Office is located in Thailand and has established links with all of the Bay of Bengal rim nations. SIBER can/should take advantage of these linkages to promote partner development in region.

Hermes: Development of MOU. Would be very interested to incorporate capacity building and training explicitly within BOBLME - SIBER partnership.

Naqvi: Possible to organize a summer school? Held in India. Training in chemical measurement, other marine observation techniques? Current capacity levels are quite low in some nations (e.g., Bangladesh, Myanmar). So training aspect may not be too intensive, at least initially.

Action item: Develop concrete plan on how SIBER can implement capacity building efforts.

Naqvi: We should have this discussion and settle on directions to pursue, prior to end of SIBER-2.

Naqvi: India has a program on ecosystem modeling (Chilikoot Lake). Short training program that will happen following SIBER-2 (Wiggert, Hood).

Wiggert (from subsequent discussion with Hermes): Related to SSC that BOBLME may be able to support travel for participants in training that would potentially be established and take place in India (INCOIS or NIO).

Africa, the ASCLME and potential linkages with IndOOS, RAMA and SIBER

Tommy Bornman

The presentation included an overview of the ASCLME, SAEON and ACEP projects in the South Western Indian Ocean (SWIO) and how these projects fit into the SIBER themes and answer the key questions relevant for the SWIO. The Agulhas and Somali Current Large Marine Ecosystem (ASCLME) project involves 10 countries of the SWIO and to date 21 research cruises have taken place of which four were dedicated RAMA and LOCO mooring cruises. ASCLME in collaboration with NOAA is responsible for the maintenance of three Atlas moorings along the 55°E line (8°, 12° and 16° South). The South African Environmental Observation Network (SAEON) is a South African Earth observation network that delivers long-term reliable data for scientific research and informs decision-making. One Long Term Ecological Research and Monitoring site has been established in South Africa and a further two are planned in the near future. In total 47 research projects are registered with SAEON in the coastal zone alone. The African Coelacanth Ecosystem Programme (ACEP) is the largest research programme (30 researchers, 17 research institutions and 51 post-graduate students) in the Indian Ocean, despite being restricted to South Africa.

ASCLME, SAEON and ACEP provides input into five of the six SIBER themes (the only theme not covered is: Physical, biogeochemical and ecological contrasts between the Arabian Sea and Bay of Bengal). All three of SIBERs science plan and implementation strategies are covered by ASCLME, SAEON and ACEP, i.e. remote sensing, modelling and *in situ* observation and potential for leveraging existing infrastructure. Theme 1: "What are biogeochemical and ecological impacts of poleward flowing boundary currents of SIO?" are covered by ASCLME, SAEON, ACEP, SANAP and SCOR WG136. Under Theme 2, the projects are involved in research on Core question 4, i.e. The Indian Ocean Dipole: how does the IOD affect regional biogeochemical fluxes, fisheries activities and the impact of higher frequency forcings and to what degree are these responses a preview of climate change. Theme 4: "Controls on, fates of, phytoplankton production in the Indian Ocean" have been studied in detail in the SWIO by ASCLME and ACEP. Theme 5: "How are warming and acidification influencing biogeochemical cycles and ecosystem dynamics" and "How are present day increases in human populations and coastal development influencing biogeochemical cycles and ecosystem dynamics in the coastal zone" are covered by ASCLME and SAEON. Theme 6: "To what extent do trophic levels influence each other?" was covered by ASCLME and ACEP research cruises. The presentation also included a few slides on possible resources available in the SWIO for SIBER related research and included Research Vessels, small boats, dive units, remotely operated vehicles, plankton pumps, etc.

Piracy Impacts on Indian Ocean Research

Sid Thurston and Tommy Bornman

Piracy is a global problem, but heavily concentrated in the northwestern Indian Ocean (Fig. 8). Piracy in this Region is becoming more serious, and it is becoming impossible to arrange research cruises in the northwestern region of the Basin. Piracy is adversely impacting Indian Ocean climate research, observations, modelling and consequently the world's ability to address the impacts of climate variability and climate change.

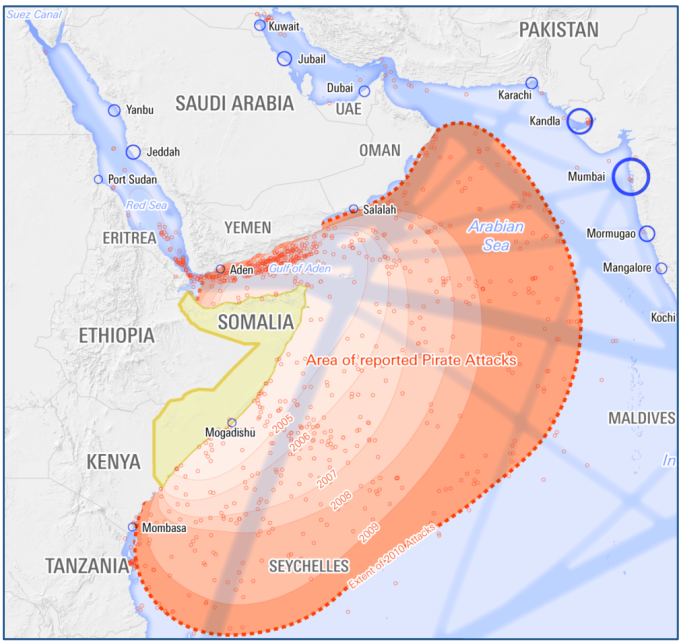

Figure 8. Expansion of piracy affected waters in the northwestern Indian Ocean.

In response to numerous Piracy incidents in the Western Indian Ocean, *Lloyds of London* declared an Exclusion Zone (EZ) within which additional premiums are required to provide insurance to merchant vessels. In early 2011 the eastern border of the EZ was extended from 65°E to 78°E. Green symbols are surface RAMA moorings. The EZ includes most implemented and planned RAMA sites along 55°E and 67°E.

Over the past 6 years, 30 of 46 planned buoys have been installed; 13 of the 16 remaining RAMA Sites are in the EZ (open green circles). Red dots are subsurface moorings. Red and yellow place marks show Pirate events for the period January 2010 through May 2011. Events along the coast of Africa and Arabia (far from mooring sites) have been omitted. Note the lack of piracy incidents in the SE portion of the EZ.

Discussion Points:

Piracy Overview: Thurston

Thurston: Security measures quotes ($19k/day for escort; $5k/day for onboard security personnel).

Bornman: Naval security is difficult to obtain because passing through EEZ is a bureaucratic snag. This requires presidential level of facilitation to allow EEZ transit. Some private ships are available. However, the ships are not outfitted with marine instrumentation. Need scientists willing to take the risk.

Recommendation: Need to publicize the problem to government bodies so that awareness is raised.

Landry: Despite knowing that Southwest Monsoon is difficult environment and piracy unlikely, this did not resonate with UNOLS/NSF regarding the Arabian Sea cruise that was cancelled.

Hood: What tangible steps can be taken by the SIBER or IOP members? IOC level, issue can be brought to assembly by IOC member. This could then result in a recommendation that is relayed up to governments.

Watson-Wright: Begin with UNESCO member states. Identify whether Somalia has a permanent delegate that could be contacted.

Meyers: In looking for a solution, spend time identifying the root causes of why piracy is developing and expanding.

Bornman: Initially, fisherman were going out to hijack vessels with fishery harvest. This has escalated to current situation. Now, re-establishing a functional Somalia government is vital, but likely to be a decades long proposition.

Summary Listing of Action Items Resulting from SIBER-2 SSC Meeting

1. Improve linkage and profile with international Carbon working groups/organizations
    a. Richard Matear is a member of IMBER/SOLAS Carbon working group. Explore whether this can be a useful pathway.
    b. Through IOC Perth, SIBER has a link to the IOCCP (through IOC-based IOCCP Coordinators) (Suggestion from D'Adamo).
    c. Why is not Chris Sabine a practical means of promoting SIBER works?
    d. What can SIBER SSC members do to promote this?
    e. Presumably, the planned installation of CO2 instrumentation on RAMA moorings will raise awareness among the Carbon community.
    f. Look to entrain: Arne Körtzinger, Chris Sabine, Nick Bates, Richard Matear, Toshiro Saino or Yukhiro Nojiri
    g. SIBER SSC: Catherine Goyet, Tim Rixen, Wajih Naqvi
    h. Form a subcommittee with external membership; Leader from SIBER will be Rixen.
2. IIOE 50th anniversary cruise
    a. This will require a concerted effort to plan a comprehensive sampling activity and recruit an established international observational team. To meet target of 2015 (or 2016), these planning needs have to be accomplished with alacrity.
    b. Short-term need is to submit convincing ship time request for the new Australian R/V Investigator. The science case in respect to Australia's interests needs to be well defined (Beckley).
    c. Longer term need is to organize cruise participants that will participate in proposal effort(s) that populate ship
    d. Active recruitment of PIs should be considered as a priority
    e. Tommy/ASCLME on board to motivate in cruise support in western IO
3. Combine SIBER mid-term open science meeting with SCOR IIOE 50th anniversary symposium (at NIO) (Raleigh will draft letter -> Wajih)
4. Formation of Communication Committee (Naqvi/Cowie/Landry/Wiggert)
    a. Provide guidance on web design and content
    b. Similarly, take lead on requesting/recruiting input for SIBER newsletter (to be published semi-annually)
    c. Develop distribution list for broadcasting to broader IO research community
    d. Consider design elements for the newsletter: Topical research activities, recent publications and project awards, letter from the chair/co-chair(?)
    e. Include "Hot Topics" element to webpage (see SSC products AI below)
    f. Web content idea: Advertise research cruises that are upcoming, facilitate interaction esp. If there is potential for space to accommodate additional scientists, (therefore promoting international collaboration)
    g. IOC-Perth has a functional website (www.iocperth.org). IRF is in this. Happy to portal SIBER via iocperth.org. In fact let's make sure we at least include SIBER as a link. IOC Perth also produces regular newsletters that are widely distributed. Please send, or CC, SIBER news to IOC Perth for inclusion. Dr Sarah Grimes will now continue with me in IOC Perth. Sarah's duties include communications in this regard.
5. SIBER Data Portal (?)
    a. Hosted at INCOIS

b. Data mining
c. Present/future activities
d. Look at IOP model of data portal (hosted at INCOIS)
e. IMBER is specific about need for a clear, demonstrated data management policy.
f. S. Africa also has data portal resources

6. Establish an ongoing generation of SIBER SSC products
    a. Formation of subgroups (naturally developing) that take on pursuit of research efforts that generate tangible outcomes (e.g., reports, papers) through relatively minimal personal effort
    b. Potential journal special issue (Cowie and others)
    c. Argos BGC float data (Wiggert/Ravi/Naqvi)
    d. ITF T:NO3-based estimate of nutrient loading (Hood/Meyers)
    e. Motivate EU proposal: Revolves around acquisition of high tech observational instruments that can be applied to piracy-impacted waters of western IO (Rixen/Hood/Naqvi)
7. SIBER Outreach and Capacity Building
    a. Capacity building and training of scientists from IO rim nations is a priority activity
    b. Leverage connections and networks that are already established by partner organizations (esp. BOBLME, ASCLME, NOAA)
    c. Consider establishing summer school(s). India as a host location has been suggested. Other locations around IO (S. Africa, Oman, Indonesia, Australia, Maldives). Should consider to keep travel logistics simple. BOBLME can potentially provide some level of travel support.
    d. Regarding relevance to Australia, IOC Perth has co-hosted a summer school recently. Feel free to consider IOC Perth for support of any summer schools planned. Supporting such (funds notwithstanding) is within IOC Perth Capacity Building objective.
    e. For Indian possibility, suggestion was for training in chemical measurement (other marine observation techniques?). Rudy (Hermes): Current capacity levels are quite low in some nations. So training aspect may not be too intensive, at least initially.
    f. India has a program on ecosystem modeling (Chilikoot Lake). Short training program will occur following SIBER-2 (Wiggert, Hood).
    g. Indian ship time (when new ship is on line) contributed to a collaborative effort in eastern BoB (Myanmar), combining with BOBLME. (Naqvi/Hermes)
8. Demonstration of Argo biogeochemical observations as a useful activity
    a. Ravi has indicated that continuation of Argo floats deployed with DO (and other biogeochemical sensors) is in danger of being phased out due to lack of apparent utilization by community.
    b. Is there interest to establish a SSC task team willing to explore these data with eye toward analysis that leads to publication of papers in peer-reviewed literature?
9. Piracy Issues
    a. What can combined IOP-SIBER-IRF panels look to do in terms of publicizing the piracy problem and who can be contacted that may have means for tangible cruise support (i.e., security)?
10. Australian NPO

a. Develop a proposal (iterate w/ Moltmann) to submit to IMOS. Keep D'Adamo in loop (Hood/Naqvi)

11. Develop connectivity to Indian GEOTRACES activity
    a. Potential ship time on cruises will be notified to SIBER community by Naqvi
    b. Request SIBER representation at GEOTRACES meeting

Appendix A. Participant List

Panel Members

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	IMBER IPO	Brest, France	imber@univ-brest.fr
W.	Watson-Wright	UNESCO IOC Paris Office	

Appendix B. Scientific Glossary

AMSA	Australian Marine Sciences Association
AS	Arabian Sea
ASCLME	Agulhas and Somali Current Large Marine Ecosystems
ATSEA	Arafura and Timor Sea Ecosystem Action http://www.atsea-program.org
BLUELink	Australian oceanic forecasting model http://www.cmar.csiro.au/bluelink/
BoB	Bay of Bengal
BOBLME	Bay of Bengal Large Marine Ecosystem
CLIVAR	Climate Variability and Predictability
CPR	Continuous Plankton Recorder
CSIRO	Commonwealth Scientific and Research Organization (Australia)
CTD	Conductivity/Temperature/Depth
DO	Dissolved Oxygen
EZ	Exclusion Zone
EEZ	Exclusive Economic Zone
FAD	Fish Accumulation Device
GEOTRACES	An International Study of Marine Biogeochemical Cycles of Trace Elements and their Isotopes http://www.geotraces.org/
IGBP	International Geosphere-Biosphere Program
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research
IOC	Intergovernmental Oceanographic Commission

IOD	Indian Ocean Dipole
IIOE	International Indian Ocean Expedition
IMOS	Integrated Marine Observing System (Australia)
IndOOS	Indian Ocean Observing System
IndoUS STF	Indo-US Science & Technology Forum
IOCCP	International Ocean Carbon Coordination Project
IOGOOS	Indian Ocean Global Ocean Observing System
IPO	International Program Office
IRF	IndOOS Resources Forum
ITF	Indonesian Through Flow
JCOMM	Joint Committee for Oceanography and Marine Meteorology
MODIS	Moderate Resolution Imaging Spectroradiometer
MoES	Ministry of Earth Sciences (India)
NERC	Natural Environment Research Council (UK)
NIO	National Institute of Oceanography (India)
NOAA	National Oceanic and Atmospheric Administration (US)
NSF	National Science Foundation (US)
OM	Organic Matter
OMZ	Oxygen Minimum Zone
OPRF	Ocean Policy Research Foundation
RAMA	Research moored Array for African-Asian-Australian Monsoon Analysis and Prediction
SCOR	Scientific Committee on Oceanic Research
SCTR	Seychelles-Chagos Thermocline Ridge
SeaWiFS	Sea-viewing Wide Field-of-view Sensor

SIBER	Sustained Indian Ocean Biogeochemical and Ecosystem Research
SOLAS	Surface Ocean-Lower Atmosphere Study
SPIS	Science Plan and Implementation Strategy
SSC	Scientific Steering Committee
SST	Sea Surface Temperature
STIO	Southern Tropical Indian Ocean
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WAGOOS	Western Australian Global Ocean Observing System
WIOMSA	Western Indian Ocean Marine Science Association

Appendix C. SIBER-2 Agenda

Day 1: Tuesday 26 JULY

1330 SIBER SSC Welcome (*R. Hood and W. Naqvi*)

1345 SIBER Update (*J. Wiggert, R. Hood and W. Naqvi*)

1400 The New SIBER IPO: (*S. Prakash*)

1415 National Perspective: SIBER India: (*W. Naqvi*)

1445 Discussion: SIBER progress to date: *(W. Naqvi and R. Hood)*

Have we made significant progress? How can additional resources for the IPO and the SSC be secured? What specific requests do we need to put to the IRF? What is the future of SIBER India?

1500 **AFTERNOON TEA**

1530 Discussion: SIBER progress to date (*continued*): *(W. Naqvi and R. Hood)*

1545 SIBER Science Plan – Overview: R. Hood

1600 SIBER Science Plan Review – Theme 1: *(L. Beckley)*

1615 SIBER Science Plan Review – Theme 2: *(J. Wiggert)*

1630 SIBER Science Plan Review – Theme 3: *(G. Cowie)*

1645 Discussion: Themes 1 – 3: *(L. Beckley, J. Wiggert and G. Cowie)*

Do these themes and science questions need to be modified or updated?

Day 2: Wednesday 27 JULY

0830 Review of Day's Agenda: (*R. Hood and W. Naqvi*)

0845 SIBER Science Plan Review – Theme 4: *(T. Rixen)*

0900 SIBER Science Plan Review – Theme 5: (*R. Hood)*

0915 SIBER Science Plan Review – Theme 6: *(M. Landry)*

0930 Discussion: Themes 4 – 6: *(T. Rixen, R. Hood and M. Landry)*

Do these themes and science questions need to be modified or updated?

0945 Discussion: Implementing the SIBER Science Plan: (*R. Hood, J. Wiggert and W. Naqvi*)

How do we move forward to coordinate and develop research programs related to these themes? What actions need to be taken? Can we motivate specific research pursuits among SSC members? Should we consider developing some kind of SIBER SSC "products"?

1000 SCIENCE TALK: New production in the Indian Ocean *(R. Ramesh)*

1030 **MORNING TEA**

1045 SCIENCE TALK: Research in the Bay of Bengal *(P. N. Vinayachandran)*

1115 PROGRAM OVERVIEW: The Indian GEOTRACES Program *(S. Singh)*

1145 Discussion: How can we leverage and coordinate with the Indian GEOTRACES program? *(Leaders: S. Singh, W. Naqvi and R. Hood)*

1200 **LUNCH**

Convene Joint Session of the SIBER SSC and CLIVAR IOP

1330 SIBER UPDATE: Efforts to deploy biogeochemical sensors in the Indian Ocean: Progress since SIBER-1 *(R. Hood)*

1345 IndOOS UPDATE: Status of IndOOS and RAMA *(G. Meyers)*

1400 SCIENCE TALK and NATIONAL PERSPECTIVE: India's mooring, Argo float and biogeochemical sensor deployments *(M. Ravichandran)*

1430 SCIENCE TALK and NATIONAL PERSPECTIVE: JAMSTEC, NOAA and FIO progress on deployment of CO_2 and other biogeochemical sensors *(Y. Masumoto)*

1500 **AFTERNOON TEA**

1530 SCIENCE TALK and NATIONAL PERSPECTIVE: The Bay of Bengal, BOBLME and potential linkages w/ IndOOS, RAMA and SIBER *(R. Hermes)*

1600 SCIENCE TALK and NATIONAL PERSPECTIVE: Africa, the ASCLME and potential linkages with IndOOS, RAMA and SIBER *(T. Bornman)*

1630 DISCUSSION: IndOOS/RAMA, the potential for deploying biogeochemical sensors, and establishing linkages with SIBER, ASCLME and BOBLME *(Y. Masumoto and R. Hood)*

1645 PROGRAM OVERVIEW and DISCUSSION: The piracy problem. How is this impacting IndOOS/RAMA? What are the ramifications for biogeochemical sensor deployment? What, if anything, can be done? *(Leaders: T. Bornman, and S. Thurston)*

Close Joint Session of the SIBER SSC and CLIVAR IOP

Day 3: Thursday 28 JULY

0830 Review of Day's Agenda: (*R. Hood and W. Naqvi*)

0845 NATIONAL PERSPECTIVE: SIBER-relevant research off of Western Australia *(L. Beckley)*

0915 PROGRAM OVERVIEW: Update on the Western Australia node of IMOS *(T. Moltmann)*

0930 NATIONAL PERSPECTIVE and DISCUSSION: Australia, and the IMOS Program and potential linkages to SIBER. *(L. Beckley, G. Meyers and T. Moltmann)*

Can a SIBER National Program be established in Australia? If yes, how do we proceed?

1000 NATIONAL PERSPECTIVE: Update on SIBER-relevant activities in Indonesia and eastern rim nations and potential linkages to SIBER *(D. Susanto and Z. Arifin)*

1030 **MORNING TEA**

1045 Discussion: Promoting SIBER in Indonesia, and other NE Indian Ocean rim nations *(D. Susanto)*

How do we increase the profile of SIBER in these countries?

1130 NATIONAL PERSPECTIVE: SIBER-relevant activities in the Maldives and potential linkages to SIBER *(S. Adam)*

1200 **LUNCH**

1330 NATIONAL PERSPECTIVE: Update on SIBER-relevant activities in Oman and the Arabian Sea *(A. Al-Azri)*

1400 SCIENCE TALK and NATIONAL PERSPECTIVE: Update on German research in the Indian Ocean *(T. Rixen)*

1430 Discussion: Strategies for tying SIBER into global carbon cycle research programs *(T. Rixen and R. Hood)*

What concrete actions can be taken?

1500 **AFTERNOON TEA**

1530 SCIENCE TALK and NATIONAL PERSPECTIVE: Update on current research plans for the Indian Ocean by JAMSTEC *(H. Kitazato)*

1600 SCIENCE TALK and NATIONAL PERSPECTIVE: Benthic process studies in the Indian Ocean: Where do we go from here? *(G. Cowie)*

1630 Discussion: Developing strategies for getting developed nations in Europe, Asia and North America engaged in SIBER *(G. Cowie, T. Rixen and H. Kitazato)*

1700 Discussion: Action items and plans for the coming year *(R. Hood and J. Wiggert)*

Are we going to pursue the development of some specific research efforts and/or SIBER SSC "products", both perhaps related to the SIBER SPIS Themes as discussed previously?

1720 SIBER BUSINESS: Funding and Resource Needs *(R. Hood, J. Wiggert and W. Naqvi)*

Funding availability from IMBER and IOGOOS for future SIBER events and activities is tenuous: National support still needs to be established not only to support the SSC activities, but also for national programs. We formed working groups dedicated to increasing national support and awareness in SIBER-1. Are these working groups working? We need to put forward a request to the IRF for support.

1740 Summary of Presentations & Discussion: *(J. Wiggert, R. Hood and W. Naqvi)*

Formulation of final recommendations and action items and development of SIBER SSC meeting reports and products

ADJOURN 2nd SIBER SSC Meeting