

**International Indian Ocean Expedition 50th
Anniversary Initiative (IIOE-2)**

***Meeting Notes from the IIOE-2 Reference Group Meeting
No 2, Qingdao, China, 20-21 November 2013***

Co-Chairs Raleigh Hood (SIBER) & Nick D'Adamo (IOC)

12 May 2014



This report can be referred to as *Meeting Notes from the IIOE-2 Reference Group Meeting No 2, Qingdao, China, 20-21 November 2013*

For noting when reading this report:

These notes were sent to all participants for revision and finalised by R Hood and N D'Adamo. They will inform the preparation of the IIOE-2 Reference Group Meeting 2 Report. The text throughout this report printed in **bold/italics** represent aspects of the discussions that constitute an action or key summary point agreed to in plenary. These **bold/italics** sections have also been consolidated, for reference, into Appendix 1 at the end of this report.

Record of revisions and edits

Date revision received	From whom the revision was received	Name of version after final editing by Nick D'Adamo based on revisions received from participants
22 April	Lynnath Beckley	IIOE2 RG Mtg2 Meeting Notes 2021Nov13 Final 120514.docx
24 April	Jun Sun	
25 April	Jim Costopulos	

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Appendix 1 Consolidation of sections in this report that were shown in bold/italics, representing aspects of the discussions that constitute an action or key summary point agreed to in plenary

1 Participant list

- Co-Chair: Raleigh Hood (USA/UMD; SIBER; also representing IMBER, IOP/CLIVAR)
- Co-Chair: Nick D'Adamo (Perth Programme Office in support of UNESCO IOC, Australia)
- IOC Representatives
 - Peter Pissierssens (Head, IOC Project Office for IODE & IODE Programme Manager)
 - Wenxi Zhu (Head - IOC WESTPAC Secretariat, Bangkok, Thailand)
 - Adote Blim Blivi (UNESCO/IOC Vice-Chairperson, Lome, Togo)
- IOGOOS Representative: Dr Rezah Badal (Prime Minister's Office, Mauritius),
- SIBER Representatives
 - Lynnath Beckley (Australia/Murdoch University)
 - Mike Roberts (South Africa/Dept Env. Affairs)
 - Mike Landry (USA/SIO)
- IOP/CLIVAR Representatives
 - Weidong Yu (China/FIO)
 - Yukio Masumoto (Japan/JAMSTEC)
 - Mike McPhaden (USA/NOAA)
 - Ming Feng (Australia/CSIRO)
- Zainal Arafin (Indonesia)
- Shao Lin (NMDIS China / GOOS SC)
- Hermann Bange (Germany/HCOR Kiel)
- Hui Liu (China/YSFRI)
- Gary Meyers (Australia/CSIRO Emeritus Professor)
- Yun Qiu (China, TIOSOA)
- Jun Sun (China, Tianjin Uni)
- Jim Costopulos (USA/Global Oceans)
- Tore Stromme (Norway/IMR)
- Iwao Ueki (Japan/JAMSTEC)
- Cabell Davis (USA/WHOI)
- Rubao Ji (USA/WHOI)
- Su Mei Liu (China/Ocean Uni)
- Gui Ling Zhang (China/Ocean Uni)
- Jing Ling Ren (China/Ocean Uni)
- Dejun Dai (China/FIO)

Local Host: Weidong Yu (China/FIO)

Sponsors: First Institute of Oceanography (China); UNESCO/IOC Perth Programme Office (PPO); IMBER; IOC WESTPAC

Welcome and introductions

Brief welcoming comments were made by Weidong Yu (FIO China), Nick D'Adamo (IOC PPO) and Raleigh Hood (SIBER).

2 Presentations and related discussions

All PPTs from the Reference Group (RG) meeting are to be collated by the Co-Chairs and held as one consolidated set at least by the IOC Perth Programme Office (PPO). They may be posted on web based portals, and will always be accessible through direct request to IOC PPO or to the authors.

2.1 Background and direction setting session.

Co-Chairs Nick D'Adamo and Raleigh Hood overviewed IIOE-2 related meetings, institutional developments and progress to date in the context of planning for the IIOE-2. Yukio Masumoto and Raleigh Hood gave detailed updates on progress in planning for a major IIOE-2 related initiative - the East Indian Ocean Upwelling Research Initiative (EIOURI), being developed by the IOP and SIBER groups as a new project for the 2015-20 period.

Presentation 1. Nick D'Adamo. Introduction to IIOE-2; Overview and outcomes from IIOE-2 RG meeting No 1 (IIOE-2 RG1), Hyderabad May 2013.

Reference was made to the IIOE-2 RG1 Meeting Notes and associated Technical Report, without needing to revisit related details (*Hood, R. R. and N. D'Adamo (Eds), Report from the IIOE-2 Reference Group Meeting No. 1, Hyderabad, India, 14-15 May 2013. IMBER Report #8; IOGOOS:PR:08:IIOE-2/RG-01; SIBER Report #5 (not peer reviewed)*). A rich set of 'big picture' science themes emerged from RG1 and these are listed within the IIOE-2 RG1 Report. Science and enabling societal benefit through Capacity Building thereof were clear emphases.

Following the IIOE-2 RG1 meeting, the IOC Assembly met at its 27th Session during June/July 2013 and adopted a positive 'Decision' on IIOE-2. An IOC Information Document was produced for this item (available from the IOC PPO or IOC Secretariat HQ Paris): *IOC/INF-1310, dated 31 May 2013, titled INTERNATIONAL INDIAN OCEAN EXPEDITION 50TH ANNIVERSARY INITIATIVE (IIOE-2)*. The IOC's Decision reads as follows.

"...Decides that it is appropriate for the IOC in collaboration with SCOR and IOGOOS, to further develop a proposal for the second International Indian Ocean Expedition in commemoration of the 50th anniversary of the IIOE-I.

*Decides to add the International Indian Ocean Expedition 50th Anniversary Initiative to the agenda of the IOC Executive Council at its 47th Session in 2014 in order to formalize, through a **Draft Resolution**, IOC's involvement in an IIOE-2, implemented for the period 2015–2020;*

Requests the IIOE-2 Reference Group and the IOC Executive Secretary to prepare the relevant documentation, timeline, organizational and financial implications for the IOC;

Urges interested Member States to support this planning effort to the best of their capacities...."

This essentially called on the stakeholders for IIOE-2 to continue to plan for IIOE-2 and make that planning available to IOC, SCOR and IOGOOS for the preparation and submission of an IIOE-2 agenda item at the IOC's 47th Executive Council meeting in July 2014.

A number of IOC Member States met at a side meeting during IOC Assembly No 27, discussing IIOE-2, and a report from that meeting has been produced, containing positive support for the IIOE-2 concept. The report is available from IOC PPO or IOC Secretariat HQ Paris and is titled: *RECORDS OF THE INFORMAL MEETING ON THE INTERNATIONAL INDIAN OCEAN EXPEDITION 50TH ANNIVERSARY INITIATIVE (IIOE-2) UNESCO HEADQUARTERS, PARIS FRANCE 4 JULY 2013 (13:00-14:00)*.

Another important form of new support was reported on. The Indian Ocean Rim Association (IORA: www.iora.net), (formerly known as the Indian Ocean Rim Association for Regional Cooperation [IOR-ARC]), currently under Australia's Chairing (2013-15), met in Perth during 30 Oct – 1 Nov 2013. IORA has a broad and important constituency in the current context, comprising 20 IO rim/island country Members, 6 Dialogue Partners and 2 Observers. For the 2013 Perth meeting, IOC PPO facilitated input on IIOE-2 and on the related planning underway. This was channelled via Australia's BoM and Department of Foreign Affairs and Trade, respectively. As a result, the IORA 2013 Perth Meeting Communique stated (Communique Item No 15):

"15. The ...'IIOE-2' ... will be a unique opportunity for regional collaboration in research, training and capacity-building. We support this important scientific endeavor to enhance our understanding of the Indian Ocean".

Furthermore, and with relevance to IIOE-2, the IORA Communique also included (Item 14):

"14. More can also be done in IORA to foster collaboration and build capacity in areas of oceanic research. We endorse work undertaken in IORA to strengthen ocean monitoring and forecasting and seasonal climate forecasting capacities and knowledge of climate change adaptation practices."

Reference was also made to the RG1 meeting's discussions on a possible governance / operational framework for the IIOE-2, with the following generic aspects of structure/governance having received broad concurrence:

- Steerage through respective institutional (including IOC, SCOR, IOGOOS [linking with IOP, SIBER, IRF]) and scientific entities.
- The creation of specific thematic 'divisions' or 'chapters' or 'sub-committees' (the nomenclature was not finalised) to provide foci for operational and institutional components and associated stakeholders of the IIOE-2.
- Secretariat support, global and regional with possible sub-regional foci, and overall with this being regarded as a critical underpinning necessity for a successful IIOE-2.

The IOTWS model was noted as a potential case study from which to draw experience from in this regard.

Reference was made to the forthcoming agenda items at the meeting that will relate to this aspect of IIOE-2, with a view to participants making commentary on further detailing the potential framework.

Participants were asked (and agreed) to note the governance structure concept that evolved from IIOE-2 RG1 and to refine and add detail to it as a result of the meeting's presentations and related discussions over the next two days of deliberations.

Discussion. Presentation 1.

Note that in this, as in all discussion sections throughout this report, questions and answers will be shown in association to those involved by reference to their initials (eg Raleigh Hood = RH), which match with the participants listed above.

CD Asked what the time frame for IIOE-2 is to be and what the challenges are believed to be. ND indicated it is being considered as 2015-20, as also noted within the IOC Decision (above). ND suggested that in respect to challenges: project management is needed (with an effective and well-resourced Secretariat structure); the development of appropriate high level science drivers; the development of an inclusive and efficient project framework, where all components of an IIOE-2 have a workable and explicit 'chapter' or 'division' or 'sub-committee' (without having yet settled on the nomenclature) to operate within and from.

WZ asked if coastal scales are to be included in IIOE-2. ND reported that they have been discussed in past iterations of the planning process, as they would again be at the meeting, and can also see no reason why coastal should not be a part of IIOE-2, and that to a large extent, this area and other such possibilities in terms of what is to be addressed or not by IIOE-2, will depend on the interests, engagement and commitments and associated resources brought to bear on those interests by the

constituents of an IIOE-2. ND also referred to the EIOURI planning underway, and the explicit links being made in terms of linkages between open-ocean and coastal scales in that initiative. ND invited WZ to facilitate IOC WESTPAC's interests in this regard.

Presentation 2. Raleigh Hood. Primary objectives and ultimate products from IIOE-2 RG2.

The key objectives for IIOE-2 RG2 were given as:

- 1) *Identify overarching science and societal drivers for IIOE-2 (day 1, all afternoon).*
- 2) *Assess ongoing and planned research activities as relevant to IIOE-2 in the Indian Ocean in the 2015 to 2020 time frame (most of day 2).*
- 3) *Identify missing stakeholders and countries and determine how to engage them including the development of strategies to motivate the formation of additional national planning committees (day 2, afternoon).*

The objectives for the overall planning process for IIOE-2 were offered as:

- 1) *Develop a Science Plan and Implementation Strategy for IIOE-2 (a draft needs to be completed in the late February / early March 2014 time frame).*
- 2) *Generate a draft resolution for submission to the IOC in June 2014.*
- 3) *Continue to motivate international participation in IIOE-2.*
- 4) *Motivate a western Indian Ocean research initiative.*

Discussion. Presentation 2.

PP suggested that a plan is also needed for IIOE-2 'data and information management'. RH strongly agreed and indicated that this should and will be explicitly addressed in the IIOE-2's Strategic Science and Implementation Plan.

RB submitted that West IO (WIO) stakeholders needed to acquire a greater sense of ownership in the IIOE-2 planning and implementation phases. RH agreed and invited (urged) those from that region to facilitate a response to this issue. RB and RH agreed, and suggested that perhaps a focus group meeting for SWIO stakeholders be held soon. There appeared to be general concurrence that this idea would be worthwhile pursuing.

PP advised that Kenya had recently received a research vessel (RV) from Belgium and that this presents at least one good opportunity for material engagement of the WIO in IIOE-2. His intervention was in reference to (see Wiki) the event of 3rd of May, 2013, when the RV *Zeeleeuw* was donated by the Flemish Government to Kenya. The oceanographic research vessel is now named RV *Mtafiti*, Swahili for 'researcher'. In Kenya the ship continues to serve marine research and is managed by the Kenya Marine and Fisheries Research Institute (KMFRI).

WY reminded all that the DBCP under JCOMM runs annual training workshops for operational oceanography in the WIO, suggesting these are an opportunity for WIO capacity building under the auspices of IIOE-2.

MR suggested that if and when the DBCP WIO workshops end, there will need to be attention to longevity of WIO data (under IIOE-2). ND responded with reference to the IOC's IODE program, and in that context referred to the presence at the meeting of Head of IODE Project Office, PP, and in further context sought IODE to engage as a key stakeholder in IIOE-2 to address and cover the 'data' needs that will inevitably become a major aspect of the IIOE-2. ND noted that 'data' was a theme of the current RG2 meeting (ref: RG2 meeting agenda items by PP).

WY asked on the accessibility of IIOE (1959-65) data and information. RH referred to: BCO-DMO (USA) curation of zooplankton data; and the CoML program (reference to OBIS). ND referred to the SCOR website on IIOE.

PP commented that the IOC data policy (underpinning IODE's philosophical and operational framework) is for open and free access of data and information.

NDA added that the GOOS principles in this context refer to timely, free and open access to GOOS data.

NDA added (on the issue of timeliness of release of data collected under IIOE-2) that there may be a need to accept, pragmatically, short term 'embargoes' on data aligned with specific researchers/countries, but that an agreement(s) (be they bi- or multi- lateral under IIOE-2) ought to be developed for the eventual timely and beneficial sharing of data/information.

SL and WZ referred to exiting formal mechanisms in this context (UNCLOS, GOOS SC).

WZ sought clarification on the status of the Reference Group and its process. ND reminded all that the IOC Assembly was briefed on the process, as well as the Reference Group aspect and the issue of stakeholder engagement currently underway. This occurred at the 27th Assembly meeting and IOC endorsed the current process (via its 'Decision' on IIOE-2).

It was generally agreed that IIOE-2 should continue to focus on the entire IO region, with effort needed to better engage W/NW IO constituents in the planning process.

The notion of holding a 'focus group' meeting for the W/SW IO was raised as a desirable follow-up to this workshop. RH and ND to work with RB to examine W/SW IO regional possibilities for such.

ND suggested the discussion on data provided motivation to ensure there is an explicit 'DATA/INFORMATION' theme in IIOE-2, linked to IODE. This notion was accepted and will be embedded in the revised governance structure for IIOE-2 (below).

Presentation 3. Raleigh Hood. Report on IIOE-2 RG1, Hyderabad, 14-15 May 2013.

The report of the RG1 meeting was referred to in this context. Highlights were presented on what was accomplished through IIOE-2 RG1:

- IIOE history and unanswered questions for IIOE-2;
- India's National Organising Committee for IIOE-2 and plans;
- IO science programs since IIOE;
- Identification of new science themes/questions for IIOE-2;
- Current ship time proposals for IIOE-2;
- Reviewed plans for major new research relevant to IIOE-2 (eg the EIOURI);
- Ditto for major events (eg NIO 50th anniversary in Goa during late 2015), and ditto for a back to back summer school in India (possibly in Goa);
- Discussed outreach and education under IIOE-2;
- Emphasised the issue of 'data/information' (consistent with the previous discussions already having occurred here at RG2 on data);

Discussion. Presentation 3.

MR emphasised the need to ensure there was a 'societal' relevancy related theme in IIOE-2.

CD agreed and referred to GLOBEC not having had such a theme (whereas he believed it could have / should have).

RH agreed.

PP agreed in indicating that he believed that IIOE-2 should certainly be driven by more than just the science imperatives, and that through effective data management and transfer for societal benefit etc the IIOE-2 could be a good platform to build capacity amongst stakeholder constituencies.

TS suggested another required theme, in relation to ecosystem assessment, with RH suggesting further that CoML be referred back to in this contest (for guidance as a case study). CD added that more than just inventory in this context would be needed, ie to include ecosystem dynamics.

SL suggested that the GOOS SC should be more engaged in the IIOE-2 process. ND responded that efforts in this context had been made (eg with input made at RG1), but agreed greater engagement would be welcome and needed.

RB suggested 'Blue Economy' objectives be a focus of the IIOE-2.

MR suggested IIOE-2 would need a division (or 'sub-committee') to explicitly engage major alliances (eg WIOMSA, IORA).

In summary, the discussion pointed to the following explicit IIOE-2 aspects requiring their own focus (eg as themes or division or sub-committees in the governance) (some of these have of course already been raised in prior iterations of the IIOE-2 planning process, but are repeated here, for emphasis).

- ***Knowledge Transfer (ie Capacity Building), where the science translates into societal benefit through training, education, mentoring, uptake etc.***
- ***Data and Information Management (as above, with IODE in mind).***
- ***Ecosystems: assessment/inventory, characterisation of key processes, including related dynamics.***
- ***An IIOE-2 'Chapter/Theme' for and to engage organisational alliances (such as WIOMSA, AMSA, SANCOR etc), and similarly;***
- ***An IIOE-2 'Chapter/Theme' for and to engage institutional alliances (high level, intergovernmental, such as IORA, COI, GOOS SC, LMEs etc).***
- ***An IIOE-2 'Theme' (high level driver) relating to derivation of wealth from the ocean (Blue Economy).***

Presentation 4. Yukio Masumoto. Report on planning for EIOURI - physical.

Two technical planning workshops for EIOURI have been completed (Yokohama April 2013 and Qingdao November 2013). The third and final is planned as a full day workshop of the IMBER Open Science Conference, Bergen, Norway, 23 June 2014. Reports from these workshops are/will be produced and available most readily through Yukio Masumoto and Weidong Yu. Many scientific objectives have distilled from the meetings, covering physical, BGC and societal aspects relating to upwelling in the EIO. One clear focus region, where there is explicit interest (with the potential for resourcing) from scientists and their countries is the Sumatra/Java upwelling system, with due consideration of links to and relevancies of upwelling in the BoB and off N/NW Australia.

The science objectives emerging from the EIOURI planning process includes characterisation of the basic water structure, and its seasonal, intra-seasonal and inter-annual variations (bio-physical). Some EIOURI pilot cruises have been mounted (eg through the MOMSEI project (ref: WY)). Local and remote influences on upwelling as well as open-coastal ocean linkages will be foci of EIOURI.

Equatorial wave propagation impacting from the open ocean to the coastal regions of the NE IO are important areas to be addressed.

A working group that will write the EIOURI plan will be established, and it will meet and write a draft plan ahead of the Bergen workshop.

Discussion, Presentation 4.

LB enquired as to the time frame for EIOURI.

YM advised it would be as for IIOE-2, which at this stage is expected to 2015-20.

Presentation 5. Raleigh Hood. Report on planning for EIOURI - biogeochemistry.

In relation to the BGC aspects of an EIOURI, the following priorities have emerged from the planning discussions so far:

- Phytoplankton bloom duration and timing off Java and Sumatra;
- IOD impacts on upwelling and phytoplankton bloom intensity off Java and Sumatra;
- Low oxygen and/or low pH impacts of upwelling;
- Anomalous nutrient stoichiometry in the Java upwelling;
- Higher trophic level responses to upwelling;
- Offshore advection of phytoplankton and coastal communities in jets and upwelling/downwelling eddies
- The need for integrated process studies;
- The need for a complimentary initiative on the western side of the IO.

Discussion, Presentation 5.

The EIOURI reports (referring respectively to physical and biogeochemical aspects) were well received and 'upwelling' as a key science theme (having agreed clear and important societal applications) was strongly supported for IIOE-2.

2.2 Science and societal drivers for IIOE-2

The next phase of the workshop focussed on presentations and discussions in relation to developing the science and related societal drivers for the IIOE-2. A number of talks on specific aspects of these topics were given.

Presentation 6. Gary Meyers. Upwelling.

It was submitted that 'upwelling' presented a worthy and important 'unifying theme' for IIOE-2, based on motivations related to:

- Upwelling's links to biology and physics through nutrient supply;
- Upwelling zones are places where Rossby and Kelvin waves strongly affect SST and climate;
- Upwelling is yet to be well simulated in climate models;
- Upwelling is a key mechanism linking basin and ocean scale processes;
- Upwelling is related to climate drivers such as ENSO, IOD, Wyrтки Jets, etc;
- Upwelling is an important factor in climate change; and
- Upwelling is an important factor in fisheries and related ecosystem dynamics and change.

The Schott *et al* (2009) paper, where important upwelling 'zones' of the IO were profiled across the E, W and N IO, was referred to as an underpinning motivation to single out this feature of the IO's ecology, for specific attention under IIOE-2. Furthermore, potential contemporary observational approaches (eg Argo, gliders) and current/prospective research projects (eg Agulhas studies, TRIO, CINDY, IMOS, EIOURI) related to examining these specific zones were highlighted as added motivation to adopting upwelling as an IIOE-2 science theme.

The case was made for 'upwelling' to be a unifying theme for IIOE-2.

Discussion. Presentation 6.

JC felt that the NW IO region appears to be relatively devoid of progress, both in terms of its current status under IndOOS and in terms of the potential for upwelling research to be undertaken, referring to 'piracy' as the acknowledged factor impeding progress. He asked whether measures such as naval escorts (to scientific vessels) etc could be invoked.

General input from the floor updated the forum on this issue: piracy was in decline however Lloyds of London maintain as non-insurable a large zone in the NW IO; measures at institutional levels through IRF and IOGOOS have been implemented to raise awareness at governmental levels.

It was generally acknowledged that the NW IO remains a priority area for IOGOOS, IOP, SIBER and IRF and should remain as such also for IIOE-2 planning.

It was again confirmed and generally agreed that 'upwelling' become a unifying science theme (having high societal relevance) for IIOE-2, with the issue of examining and motivating interest and research on upwelling in the WIO to complement EIOURI emphasised.

Presentation 7. Mike McPhaden. Monsoons.

The scientific and related societal importance of the IO's role in driving, modulating and influencing monsoon dynamics was presented, with reference to links to extremes in oceanographic and weather responses (including hazards and threats to food security, human safety etc).

The role of maintaining and enhancing the Indian Ocean Observing System (IndOOS) (through the auspices of IOP, SIBER, IRF, under IOGOOS, IMBER, CLIVAR) was emphasised in this context, with reference to IIOE-2 planning.

Discussion. Presentation 7.

WY enquired as to the importance therefore of including atmospheric considerations in IIOE-2.

MM replied that it should, as it was for the original IIOE. He added that the IOP community had made solid efforts to reach out to the CLIVAR Monsoon Panel in the sense of forging integration across coupled ocean-atmosphere research in the IO. These efforts will be ongoing.

GM pointed out the need to incorporate biology into monsoon research. RH agreed (from the SIBER perspective) and submitted that any reference to monsoons would/should by definition, in the current context, imply integrated physics/BGC considerations.

It was generally agreed that one unifying theme for IIOE-2 should be along the lines of 'the IO's role in coupled ocean-atmosphere dynamics with reference to related extremes and hazards, with due reference to trends under climate change'.

Presentation 8. Ming Feng. Extreme events under a changing climate and global warming.

The sporadic upwelling off Western Australia that occurs in what is considered ostensibly to be a 'downwelling' system (the Leeuwin Current off N/NW/W Australia) was highlighted in terms of its relevance to local climate, physics and BGC. Supporting results from observations (eg from Australian

IMOS), analyses and modelling in this respect were presented, as were related calculated upwelling indices, having space and temporal underpinnings. The role of inter-connected open ocean – coastal processes in influencing biological phenomena off Western Australia was highlighted (eg cross-shelf rock lobster recruitment that relies on onshore geostrophic flow transport).

The role that a changing climate will play in altering the phenomena was emphasized as a key research pursuit for IIOE-2.

The need to include themes related to ‘marine’ extremes was also highlighted. This was underscored by reference to the so called ‘marine heat wave’ that recently (early 2011) occurred off Western Australia (anomalously high temperatures at 3-5 deg C above long term averages) in the Leeuwin Current and adjacent ocean.

Discussion. Presentation 8.

GM supported the presentation’s focus on marine extreme events, in the context of IIOE-2.

WZ submitted that Sea Level Rise, in the context of climate change, be an important extreme to be considered. This was agreed.

The discussion generally converged on the agreed need to have ‘marine extreme events’ as one unifying theme for IIOE-2, with reference to the influence of a changing climate.

Presentation 9. Mike Roberts. West Indian Ocean.

Some of the key drivers for Africa / West IO, in terms of what an IIOE-2 could deliver, were listed as:

- Poverty and growing their economies (tourism, fisheries, oil & gas);
- Food security (artisanal and industrial fisheries, climate, rainfall);
- Climate (Change) and extreme events (droughts, TCs);
- Coastal erosion and sea level rise;
- Ecosystem preservation and performance.

In this context, it was submitted that IIOE-2 should develop a close relationship with WIOMSA, as an alliance that includes many key WIO constituents.

Discussion. Presentation 9.

General comments were made on the cross-cutting nature of the objectives in MR’s talk, eg coral bleaching and IOD.

General comments were made, in response to the talk, on the need for improving ocean observations, characterisation of processes, prediction (re drivers of climate); transmission of weather patterns from ocean to terrestrial environs; and hazards related to the ocean (marine and climatic).

ND, GM and MM suggested, and it was agreed, that the stated priorities of WIO constituents pointed generically again to the unifying theme of ‘the ocean’s role in weather’ as relevant to coastal and terrestrial productivity (eg fishing, agriculture) and safety (eg hazards – marine and land).

It was generally agreed that WIOMSA be invited to engage in IIOE-2, through the inclusion of a chapter/division for such alliances (that addresses knowledge transfer, from science to societal benefit/uptake) in the governance structure of IIOE-2.

Presentation 10. Yukio Masumoto. Indian Ocean Dipole.

It was emphasised that in terms of societal importance, the Indian Ocean Dipole mode (IOD) is a key climate mode for the tropics, and itself involves many processes with a variety of temporal and spatial

scales. Research on the mutual interactions among those processes is fundamentally important for a better understanding of the IOD and its prediction/predictability.

The IOD's impacts, in terms of correlations to cool and warm weather and rainfall and droughts, were strongly emphasised. A positive IOD (where the IO is relatively warmer in the west) correlates with relatively strong rainfall (with threats of excessive rainfall, floods) over east Africa.

Reference was also made to the 'Ningaloo Nina' and potential correlation to IOD's phase. The Ningaloo Nina refers to the oceanographic heating event during early 2011 off Western Australia, when 3-5 deg C SST above long term averages, were recorded for a number of weeks.

Discussion. Presentation 10.

General discussion took place with agreement on the importance of having a unifying theme involving IOD – in terms of observing it, characterising it and improving the prediction and predictability of it, with due reference to its role in both oceanographic and adjacent terrestrial extremes (marine and climatic).

It was agreed that the 'IOD characterisation, prediction/predictability and relevancy to marine and climatic extremes' should constitute a unifying theme for IIOE-2.

The generic issue contained in the talk also motivated a general discussion on the value of IIOE-2 and its imminent data and information in terms of examining how the ocean and climatic phenomena have changed since the IIOE of the 1960s.

It was agreed that a unifying theme for IIOE-2 should cover the issue of 'changes in the IO and adjacent terrestrial environs since the IIOE of 1959-65'.

Presentation 11. Weidong Yu. East African Monsoon.

The influence of the WIO on rainfall over East Africa was discussed in the context of the performance of models in simulating the East African Monsoon and in turn with respect to the contribution of SST forcing.

Presentation 11. Discussion.

The discussion again led to emphasis on the need to characterise the relationship of the IO (focussing on WIO) and climate extremes over Africa (specifically East Africa). The contrast was highlighted between the timing of the occurrence of the annual Asian Monsoon (during the Austral winter), Australian Monsoon during the Austral summer and the East African monsoons (referring to the ~3mth long rains around AMJ and the ~ 1mth short rains around November) which occur in between the respective Asian and Australian monsoons.

Rainfall over East Africa was of course referred to as a most critical issue for its communities, with related extremes (eg droughts, floods) having profound human impacts.

The merits of integrating efforts examining the various monsoon phenomena (in terms of coupled ocean-climatic issues) around the IO region as a whole was emphasised.

There was general agreement again on the need for IIOE-2 to have as a unifying theme 'the role of the IO on climate extremes'.

Presentation 12. Rezah Badal. National Ocean Economy Dialogue.

This talk introduced with emphasis the role of the oceans as drivers/providers of wealth for its communities (referred to as the Blue Economy concept), with reference to the following aspects that can provide wealth and societal benefit: hydrocarbon & minerals; fishing, seafood processing and aquaculture; deep ocean water applications; marine services; marine tourism; marine biotechnology;

ship registration; marine finance; marine ICT; port related activities; marine renewable energies; ocean knowledge.

In this context, it was also emphasised that Mauritius, as an exemplar and generic case in point, recognises the need for an appropriate characterisation of the bio-physical dynamics of the region from which wealth from the ocean is to be derived (covering observations, processing, theory, modelling, knowledge transfer). Of interest here was the need for ecological detailing of the new SW IO EEZ region recently acquired by Mauritius per se and then also that which has been recently co-acquired under joint management by Mauritius and Seychelles.

This pointed to the need for the types of advances in these areas that could be gained from an integrated effort such as an IIOE-2.

Discussion. Presentation 12.

There was general discussion leading to agreement that IIOE-2 should have as a unifying theme an objective referring to 'sustainability of a Blue Economy in the IO'.

Presentation 13. Raleigh Hood. Biodiversity, ecosystems and biogeochemistry perspectives.

The SIBER SPIS was referred to in the current context as one which provides a well-founded and relevant set of science drivers that can be drawn on for IIOE-2:

SIBER Regional Scientific Themes:

- **Theme 1: Boundary current dynamics, interactions and impacts** (How are marine biogeochemical cycles and ecosystem processes in the Indian Ocean influenced by boundary current dynamics?)
- **Theme 2: Variability of the equatorial zone, southern tropics and Indonesian throughflow and their impacts on ecological processes and biogeochemical cycling** (How do unique physical dynamics of the equatorial zone of the Indian Ocean impact ecological processes and biogeochemical cycling?)
- **Theme 3: Physical, biogeochemical and ecological contrasts between the Arabian Sea and the Bay of Bengal** (How do differences in natural and anthropogenic forcing impact the biogeochemical cycles and ecosystem dynamics of the Arabian Sea and the Bay of Bengal?)

SIBER General Scientific Themes:

- **Theme 4: Controls and fates of phytoplankton and benthic production in the Indian Ocean** (What are the relative roles of light, nutrient and grazing limitation in controlling phytoplankton production in the Indian Ocean and how do these vary in space and time? What is the fate of this production after it sinks out of the euphotic zone?)
- **Theme 5: Climate and anthropogenic impacts on the Indian Ocean and its marginal seas** (How will human-induced changes in climate and nutrient loading impact the marine ecosystem and biogeochemical cycles?)
- **Theme 6: The role of higher trophic levels in ecological processes and biogeochemical cycles** (To what extent do higher trophic level species influence lower trophic levels and biogeochemical cycles in the Indian Ocean and how might this be influenced by human impacts, e.g., commercial fishing?)

Then, LiCO as the follow-on initiative (being a plan more than a program at this stage) to CoML, was also referred to as providing biodiversity related themes for IIOE-2. (CoML = Census of Marine Life program; LiCO = Life in a Changing Ocean program). This was consistent with related input and agreement for LiCO's relevance to IIOE-2 from the RG1 meeting in Hyderabad.

LiCO's generically relevant themes (for IIOE-2 big picture science themes) are:

- 1) Biodiversity discovery in space and time, by addressing questions of global biogeography patterns, sentinel species of biodiversity change and species identification;
- 2) Biodiversity and ecosystem functions and services, by addressing questions of variability, interactions, vulnerability and socio-economic implications; and
- 3) Biodiversity and human exploitation, by addressing themes of change, processes/mechanisms, anthropogenic impacts and sustainability.

Discussion. Presentation 13.

There was general discussion and agreement that the specification of the IIOE-2 science drivers can and should draw on the ecosystem and biogeochemical objectives inherent in the six high level themes of the SIBER program and the three of the LiCO program.

Presentation 14. Herman Bange (with proxy input from Martin Visbeck). Biogeochemical and ecological perspectives.

This presentation complemented and added to those earlier on the subject of BGC and ecological objectives.

The talk, in summary, submitted that:

Designation of over-arching science drivers for IIOE-2 should be guided by the following points:

- The IO remains the least sampled of all the world's oceans. For example, it has had the least number of CO₂ fugacity (fCO₂) measurements of all the oceans.
- Three major stressors are (with the N IO being particularly vulnerable to them):
 - Warming;
 - De-oxygenation (with the IO exhibiting an expanding O₂ minimum zone);
 - Acidification.
- Eutrophication (with some areas exhibiting relatively intense levels of eutrophication (eg BoB)).
- Atmospherically derived pollution in 'haze' clouds (eg the 'Asia Brown Cloud'), deriving from the N IO land regions and propagating southwards over and onto the N IO. These influence and impact on South Asian climate and hydrological cycles.
- Increasing aerosol loads (particularly from the NE African and Middle Eastern regions). The Aerosol Optical Depth in the N IO is increasing, particularly in the NW IO. In this geographical context, note was made of the intense interest of atmospheric chemists in troposphere/stratosphere mixing (including atmospheric upwelling). The N IO region is a 'scientific hotspot' of interest.

Designation of over-arching societal drivers for IIOE-2 should be guided by:

- Change in coastal environments (eg, referring to: sea level rise; mangrove loss, etc). The role of the IO's warming (which is not homogeneous around the IO) is critical here in the context of future sea level rise and its temporal and spatial characteristics.
- Changes in monsoon systems and related upwelling intensity (eg referring to productivity, fisheries etc).
- The role of sediments in marine ecosystems and BGC cycles.
- Hazards and threats to humans and ecosystems as a result of intensification of cyclones.

- Loss of marine biodiversity – the consequences?
- Overfishing – the consequences? (in relation to the general point of exploitation of the IO's natural biotic resources): "which natural and anthropogenic processes are controlling biological production and fish stocks?".

Discussion. Presentation 14.

There was general agreement with all points raised in the Hermann Bange / Martin Visbeck talk, and the distillation of the key guiding points (some reinforcing existing points and some new) for designating IIOE-2 over-arching objectives in the areas of:

- ***Improving the IO baseline inventory (bio-physical).***
- ***IO wide ocean stressors – warming, de-oxygenation and acidification.***
- ***Atmospheric pollution from haze clouds and aerosols, and impacts on the ocean.***
- ***Coupled ocean-climatic hazards (including sea level rise).***
- ***Characterising and responding to unsustainable natural resource exploitation.***
- ***Characterising and responding to eutrophication.***
- ***Characterising marine biodiversity and threats to it.***
- ***Role of sediments derived from coastal sources, and impacts on IO ecosystems.***
- ***Monsoon characterisation (current and under changing ocean-climate conditions).***

Presentation 15. Cabell Davis. Effects of upwelling on zooplankton and links to higher trophic levels.

This presentation brought focus to the importance of considering upwelling as a unifying theme, with particular context on its effects on zooplankton, coral ecosystems, and related fisheries.

The role of upwelling in enhancing resilience of biota to climate change phenomena was highlighted (eg bleaching, acidification).

The role of the monsoons in these subject areas was emphasised.

The importance of the Indonesian-Australia Basin (IAB) region (ie between N-NW Australia and SEA) was also highlighted in the context of understanding how coastal upwelling, interacting with the ITF outflow, affects higher trophic levels, including coral growth, coastal fisheries (eg sardine) and offshore Tuna in respect to the known (albeit with limited understanding) spawning/nursery area within the IAB.

Discussion. Presentation 15.

There was general agreement that the material presented by Cabell Davis on zooplankton/upwelling was compelling and note was made of its link to the EIOURI objectives. In this context, there was general agreement as to the designation of a science driver along the lines of: Effects of upwelling on zooplankton and links to higher trophic levels.

Presentation 16. Jun Sun. Bottom-up / top-down control to the primary production in the EIO.

This talk centred on the science of examining in better detail aspects related to the IO's 'biological pump'. Historical features of the N IO that acted as motivation for the talk included: plankton blooms, hypoxia, oligotrophy, monsoon dynamics, Indo-Pacific warm pool and related IOD/ENSO effects, CO₂.

The presentation distilled into some scientific issues submitted as input to forming up the high level drivers for IIOE-2:

- Phytoplankton community distribution and succession in the East Indian Ocean (EIO).

- Primary production and control factors.
- The efficiency of phytoplankton in the biological pump.
- Spatial distribution and diversity of microbes.
- The diversity of anaerobic ammonia oxidation (Anammox) bacteria.

Two hypotheses were offered for consideration.

Discussion. Presentation 16.

Material well noted for objective setting and in terms of links with other agreed priorities, including EIOURI.

Presentation 17. Rubao Ji. Relating connectivity, phenology and biogeography.

This talk emphasised the importance of examining aspects of the IO's natural and anthropogenic characteristics across the physical, ecological and anthropogenic spheres. Ecological connectivity, as driven by bio-physical processes was highlighted.

Discussion. Presentation 17.

General discussion focussed on:

Phenology – can this aspect form a basis for comparative work in respect to IIOE-1 vs IIOE-2 and thence setting up for an IIOE-3 perhaps, and in turn then having three data sets from which to make comparisons through?

Biogeography – It was felt that the zooplankton data from IIOE-1 may provide a useful, comparable data set, if zooplankton were to be addressed in IIOE-2.

Population connectivity – in respect to bio-geographical connectivity, the corals were highlighted as a prospective area to examine in the region (noting, as a case in point, the north to south gradients, connections and genetic gradations that occur in corals from SEA down to the temperate E IO zone).

In general, the material was therefore well noted for objective setting and in terms of links with other agreed priorities.

Presentation 18. Su Mei. Nitrogen – measurement methods for low nutrient concentrations.

Information on low concentration methods to characterise nutrients, such as for the N cycle, were presented, and in the context of facilitating studies into, for example, eutrophication.

Variables addressed were: Nitrate, Nitrite, Ammonium, Phosphate, dissolved silicates, and measurement methodologies to deal with these.

Discussion. Presentation 18.

Material noted for objective setting and in terms of links with other agreed priorities.

2.3 Chairs' and participants' summaries of the presentations on science and societal drivers

Presentation 19. Raleigh Hood. Summary of science (physical, atmospheric, biogeochemical) and societal drivers.

Raleigh Hood consolidated his summation of the preceding presentations on science and societal drivers into three generic sub-groups: Physical, BGC/Ecosystem and Societal. These were generally accepted as relevant to an IIOE-2.

Physical Oceanography and Atmospheric Science Drivers:

- *Upwelling dynamics and variability.*
- *Monsoon variability and predictability.*
- *Extreme events.*
- *Climate variability and change.*

Biogeochemical and Ecosystem Science Drivers:

- *Ocean stressors (warming, de-oxygenation, acidification, eutrophication, atmospheric pollution).*
- *Biodiversity loss, changes in phenology and biogeography.*
- *The Indian Ocean's role in the global nitrogen cycle.*
- *Fisheries: recruitment, productivity and links to biogeochemistry and physics.*

Societal Drivers:

- *Food security and fisheries (commercial and artisanal, overfishing).*
- *Change in coastal environments (sea level rise, coastal erosion, loss of mangroves).*
- *Human impacts of climate change, extreme events and monsoon variability.*
- *Biodiversity loss and ecosystem preservation for tourism and fisheries.*

Discussion. Presentation 19.

General agreement. Further discussion held over for later agenda items on Day 2

However, WZ sought clarification on the emphasis that would/should be placed on Capacity Building in IIOE-2. RH re-assured participants that, as was the case for RG1 and as was reported in the RG1 Technical Report (Hood and D'Adamo, 2013), CB is seen now and will be seen in future IIOE-2 planning, as a fundamentally and critically important component of IIOE-2, where science and societal benefits are linked.

Presentation 20. Nick D'Adamo. Summary of science (physical, atmospheric, biogeochemical) and societal drivers.

Themes

Nick D'Adamo presented a list of focus area themes that he distilled out of and/or interpreted from the presentations and related discussions (both during the sessions and throughout discussions during the breaks and in the margins of the agenda items), as follows. These were generally accepted as relevant to an IIOE-2.

- *In respect to SIBER's relevant themes: all of SIBER's themes are relevant to draw from, particularly under the motivation of understanding the IO's role in sustaining life (natural and anthropogenic), and BGC and ecosystem processes (6 themes to distill).*
- *In respect to IOP's relevant themes: as for SIBER, all of IOP's themes are relevant.*
- *Data & information management: a key area of priority, particularly in respect to IIOE-2 data/information curation, accessibility, longevity, utility for societal benefit. This emerged as a key area requiring a dedicated chapter/division in the IIOE-2 sub-committee structure, and links to IODE were seen as fundamentally important in this context.*
- *GOOS: IIOE-2 can and should have a major role in enhancing GOOS in the IO, and to this end a link between IIOE-2 and the GOOS SC is desirable and should be established. Again, the IIOE-2 governance framework can cater for this priority through an appropriate sub-committee structure.*
- *Revisit and examine W/SW IO relevancies and themes for IIOE-2 (possibly through a dedicated focused W/SW IO workshop).*
- *Create a specific Knowledge Transfer theme through an IIOE-2 sub-committee. This derives from the general and repeated references made at this and the RG1 meeting that an IIOE-2 with science pursuits in the absence of aligned, complementary and harmonised Capacity Building (CB) would be seen to be retrograde and narrow and lacking optimal societal relevance. Consistent input from stakeholders and institutional champions (eg IOC and IOGOOS related stakeholders and commentators) indicates that an IIOE-2 without appropriate and meaningful CB would receive much less support at/from their levels than otherwise would be afforded.*
- *Create a specific mechanism to engage and work with high level Governmental, institutional stakeholder associations, groups - again, through a dedicated sub-committee (engaging IORA, COI etc).*
- *Upwelling: examine the regional interest, feasibility and prospects for extending the strongly supported EIOURI research theme to the entire IO, either through a dedicated SWIOURI or an IO wide expansion of the EIOURI to an 'Indian' OURI (ie IOURI).*
- *IO's role in creating or modulating coupled ocean-atmosphere extreme weather hazards (eg monsoons, cyclones, droughts, storms, floods ...). The question arose: do we dedicate a theme to monsoons and address the 'others' in a dedicated complementary theme, or do we bring them all together under one umbrella theme? In this context we would note and refer to JCOMM as a key high level link.*
- *IO's role in creating or modulating extreme marine hazards (eg bleaching, other manifestations of temperature stress (recall Ningaloo Nino), acidification, transport of hazardous wastes [radiation, toxicant]), and again in this context we would note and refer to JCOMM as a key high level link.*
- *IO's role in global climate cycle / climate change understanding/predictability. This would involve an examination relating to the IO per se but also in relation to the IO as a conduit/conveyer of mass and energy through the spectrum of processes discussed at the workshop (and linking closely to motivations obtainable from IOP and SIBER science priorities).*
- *The Indian Ocean's physical dynamical and BGC links with its neighbouring oceans and marginal seas and the importance of the IO as a conduit/connector with these other bodies of water and as a major routing influencing global hydrological, BGC and climate cycles.*
 - *In this context we note the links that would be sensible to make with:*

- *the Southern Ocean Observing System at the IO/SO interface and via boundary currents that propagate pole-ward (eg Agulhas and Leeuwin Currents) and counter-currents that propagate equatorward;*
 - *with the Pacific Ocean (noting the bio-physical transmitting characteristics of the ITF); and*
 - *with the Atlantic ocean (noting the Agulhas Leakage from the IO to the Atlantic).*
- *Improving bio-physical baselines/inventory. This is relevant in terms of both a pure scientific pursuit (the fundamental Voyage of Discovery motivation) and also in its relevancy to societal benefits. In this context, consideration would be given to biodiversity (bio-discovery, biotechnology, pharmaceuticals from the ocean), carbon, bathymetry, habitats, geological histories in substrate, corals etc, species discoveries. The priorities to be developed would draw importantly and heavily from the already well-reasoned and peer reviewed priorities that have emerged from the LiCO and CoML programs.*
- *IO and the BLUE ECONOMY: this was raised as a key driver for IO stakeholders, in terms of the potential value of an IIOE-2 in enhancing the prospects to derive wealth from the oceans under sustainable management frameworks. To that end, the improved scientific underpinning and knowledge transfer that could be gained from IIOE-2 adds to the compelling attractiveness of mounting an IIOE-2, appropriately framed. In this context, foci would include both improved and new observatories, process understanding, habitat inventories, facilitation of exploration, sustainable utilization of natural resources etc.*
- *Change in the IO: the prospect to examine changes in the IO's ecology and coupled climatic states is compelling. This would involve examining the results of the IIOE-1 of the 1959-65 period, through to the JGOFS, WOCE and IOP/SIBER eras and thence to what would emerge from an IIOE-2, as appropriate and possible.*
- *Linkages between atmospheric pollution/material sources and the IO's ecosystem, in term of both characterization of processes and inventories of the state of health of marine and coupled atmospheric systems.*

Governance

Nick D'Adamo interpreted the results of presentations and associated discussions in terms of how the evolving IIOE-2 programmatic framework, or governance framework, would now look. This was presented in terms of an organogram, but can be best presented herewith as follows. There was general acceptance in principle with maintaining this structure for further discussion under the IIOE-2 planning process:

- *Steerage through respective institutional and scientific entities (including IOC, SCOR, IOGOOS [linking with IOP, SIBER, IRF]).*
- *Guidance for the science and societal benefit areas of IIOE-2, and this might include:*
 - *Scientific Reference Group;*
 - *Societal Benefit / Capacity Building / Knowledge Transfer Reference Group.*
- *The creation of specific operational components (perhaps to be referred to as thematic 'divisions' or 'chapters' or 'sub-committees') in order to provide foci for operational components and specific stakeholder categories of the IIOE-2, including:*
 - *Cruise coordination (planning, coordination, regular review, reporting, standardisation of methodologies, cross-cruise communications etc);*
 - *Special events (such as the Indian NIO 50th Anniversary celebration symposium, planned for 2015 [noting NIO's birth in alignment with the original IIOE]);*
 - *Scientific symposia and conferences (such as IIOE-2 annual conferences, and related meetings);*

- *Data and information management under the IODE framework (the legacy of longevity and utility of data and information and products/outcomes/outputs from IIOE-2);*
- *High level institutional partnerships (eg IORA, COI, IOC Regional Subsidiary Bodies and Decentralised Offices, AMCOMET, AMESD, LMEs etc);*
- *Capacity Building (education, in-situ – such as on-board training on cruises, ‘laboratories/universities of the sea’), CB workshops, up-skilling, mentorship, studentships, exchange programs, utilisation of the IIOE-2 data in CB;*
- *Communication & Outreach (building a constituency, dissemination of the results, engaging the broader community);*
- *Knowledge Transfer (translating science into policy, management, applied utility, including the Blue Economy theme);*
- *National IIOE-2 Committees (coordinated national approaches to IIOE-2 engagement, inter-committee integration);*
- *Research initiatives (eg EIOURI, LOCO);*
- *Scientific association partners (eg WIOMSA; AMSA; GEOTRACES, CORDIO, IMOS Australia, SANCOR, integration with UNESCO Category 2 and RSB training centres and similar entities (eg ITCOcean India)).*
- *Secretariat support, with this being regarded as a critical underpinning necessity for a successful IIOE-2.*
 - *The overall model emerging included a regional operational base, for example as has been provided so far through the IOC Perth Programme Office, working collaboratively with what hopefully would be the formation of sub-regional operational foci, and under the overall auspices of global coordination through the IOC HQ Secretariat via something akin to say an IIOE-2 Secretariat ‘Project Office’.*
 - *The IOTWS, GOOS SC and SOOS coordination models were noted as potential case studies from which to draw experience from in this regard.*

Discussion. Presentation 20.

General agreement. Further discussion mostly held over for later agenda items on Day 2.

Presentation 21. Mike Landry. Summary of science (physical, atmospheric, biogeochemical) and societal drivers.

Mike Landry made the general point that since the original IIOE era, when there was a relatively limited technological capacity for ocean measurements, much has improved in terms of our capacity to measure key variables, in-situ and off-site. The point was made that there was now a greatly improved feasibility and capacity to undertake process studies and that this factor should drive experimentation and process study work in the IIOE-2.

Mike Landry provided his high level summation (which was generally accepted as relevant to IIOE-2) of some of the key points to have arisen out of the preceding presentations on science and societal drivers:

Compelling physical questions:

- ***Upwelling circulation & transport mechanisms (eg eddies).***
- ***IOD initiation and variability.***
- ***Climate sensitivities.***

Biogeochemical linkages:

- ***Nutrient sources and fluxes.***
- ***Biological transformations of nutrient signals.***

- ***Production processes, process-based experiments.***
- ***Food web pathways and trophic transfer efficiencies.***

A note was also given on some of the key elements that could underpin the design and implementation of ideal field and analytical/predictive experiments for IIOE-2, including:

- Addressing time scales from multi-annual to decadal (to capture, for example, IOD scales);
- Undertaking seasonal scale monitoring (eg using gliders, moorings);
- Working through survey cruises, to cover integrated environmental, biological and biogeochemical fields;
- Specifically designed survey cruises to examine seasonal and IOD related states; and
- Encouraging strong multi-disciplinary interactions (eg between experimentalists and modellers, working together to arrive at optimal experimental design and to undertake interpretations and extrapolations of results across varying time scales, in both retrospective and predictive modes).

Discussion. Presentation 21

General agreement. Further discussion held over for later agenda items on Day 2.

2.4 Stakeholder/country presentations

Presentation 22. Jim Costopulos, Global Oceans: Regionally-deployed research vessels as a facilitating/coordinating mechanism for operational support.

This talk outlined how Global Oceans (www.global-oceans.org), a US-based 501(c)(3) non-profit organization, has developed an operational strategy and a global supply network to mobilize private-sector resources, specifically offshore supply vessels (OSVs), modular labs, instrumentation and logistics support, for short-term use as dedicated oceanographic research platforms. This infrastructure strategy is already a proven methodology for extending research capacity; however Global Oceans' objective is to optimize the process in a way that can be predictably and cost-effectively utilized by investigators and rationally integrated into expedition planning.

The stated objective of the IIOE-2 initiative for launching a "coherent basin-wide 5 year 'integrated and collaborative' voyage of discovery"; together with the wide disciplinary breadth of already proposed study initiatives, was referenced as driving three principle points: 1) establishing a balance in the IOC proposal between what is most important to achieve with what is feasible in the context of IIOE-2 requires an assessment of likely available resources; 2) the complete set of resources that will be contributed (vessel proximity, frequency, capacity, etc.) is not yet fully known; and 3) an infrastructure approach such as that proposed by Global Oceans utilizing regionally-deployed vessels that are project-adapted and scalable "on demand" can usefully inform the IIOE-2 planning process.

It was emphasized that among the over 3,000 vessels serving the offshore energy industry and able to be time-chartered and configured for research, approximately 1,400, or 45% of the global fleet, operate in the Indian Ocean basin. This resource pool is of significant value when contrasted with the well-documented challenges of transiting dedicated RVs from North America, Japan and Europe to the Indian Ocean. Regionally-deployed vessels, science-configured and mobilized as international, multidisciplinary, shared-cost IIOE-2 platforms – independent of a single national interest or science agenda – will therefore complement existing resources and add significant, cost-effective capacity and scope to the IIOE-2 plan.

A map was presented proposing to aggregate potential Global Oceans' deployments for IIOE-2 from six principal ports, corresponding to where resources are concentrated and to enable effective transit into any region of the IO basin and parts of the Southern Ocean. These ports included Dubai, Mumbai, Singapore, Dampier, Perth and Durban.

A brief description of the GO-CEPT expedition planning tool developed by Global Oceans in collaboration with the University of California, Santa Barbara in the US, was presented. This secure, online, interactive research expedition planning tool integrates GIS-enabled map layers, activity based graphics, a collaborative forum, cruise track and activity planning, and a technical resource database. Global Oceans proposed to establish and host IIOE-2 expedition modules and full use of GO-CEPT at no cost to the IIOE-2 community over the expedition timeframe.

Subsequent to the meeting in Qingdao, Global Ocean prepared and submitted to the IOC Perth Programme Office a more detailed framework document (complementary to the PPT) outlining how the Global Oceans model might specifically be applied to address operational and logistical challenges; help to enable more effective collaboration; and extend the spatial and temporal footprint of studies brought under the IIOE-2 umbrella by participating institutions and nations. The paper is entitled: *Global Oceans & the IIOE-2 Initiative: Rationale & Proposed Framework for Integrating Regionally-Deployed Research Vessels in Support of the IIOE-2 Science Agenda (version dated 13 December 2013)*, which is posted on the IOC PPO website.

Global Oceans' analysis of the IIOE-2 plan in the follow-on framework document poses two principal challenges to achieving IIOE-2's wide-ranging agenda, and has proposed some solutions:

- *Whether a sufficient number and frequency of national research vessels can be committed in the region over the five-year expedition period to fully support the agenda; and*
- *That organizing discrete expeditions to fully support the geographic, temporal, disciplinary and operational diversity of the proposed studies on an "integrated and collaborative" basis presents a high degree of logistical complexity*

Global Oceans brings an organizational approach that addresses the first point above by offering an operating model that can dynamically augment and expand the physical capacity for research and observation in remote, open ocean regions of the Indian Ocean with regionally-deployed vessels.

It is further proposed that logistical complexity issues can be partially addressed by the integration of the GO-CEPT planning system, provided at no cost to the IIOE-2 community. GO-CEPT could contribute to the effective alignment between the resource and timing needs of IIOE-2 projects and the optimized integration of available science assets.

The Global Oceans paper outlines four main applications where the Global Oceans infrastructure model generally could have potential impact on the success of IIOE-2:

- *To augment the work of developed research plans conducted aboard national vessels brought under the IIOE-2 umbrella as "silo'd" projects with additional expeditions to extend the resolution and scope of research data and involve others in the wider IIOE-2 community to contribute to these studies.*
- *To aggregate individual projects not associated with institutional vessels on common, shared platforms. These could incorporate capacity building and training for students and early career scientists in regions where traditional resources are scarce or non-existent.*
- *To facilitate multi- and interdisciplinary collaborative research and other operationally complex studies. These might include biodiversity-focused studies proposed by the Life in a Changing Ocean program; the interdisciplinary basin-wide Myctophid study proposal; and others.*
- *To operationally facilitate and encourage new study proposals from international programs and institutions in a position to propose and fund new Indian Ocean research, which might otherwise not be proposed due to traditional resource constraints in the region.*

Discussion. Presentation 22.

Noted with relevance to IIOE-2.

Presentation 23. Wenxi Zhu. IOC WESTPAC.

This presentation provided a detailed overview of the portfolio of interests and programs of the IOC's Sub-Commission for the Western Pacific (WESTPAC), reviewing in that context some of the key bio-physical idiosyncrasies of the WESTPAC area of interest. It overviewed WESTPAC's key program framework, including those under the auspices of South East Asia GOOS (SEAGOOS) and North East-Asian Regional GOOS (NERAGOOS), in the context of potential links with IIOE-2 objectives.

For example, the potential for IOC WESTPAC capacity building activities to link with IIOE-2 objectives in that area was highlighted. Furthermore, some of the key science based projects under IOC WESTPAC (such as relating to MOMSEI, ocean forecasting) were detailed as having overlapping domains with the NE IO and hence relevancy as potential components in an IIOE-2 science framework.

Participants were also made aware of the forthcoming: Indo-Pacific Ocean Forum "Charting the Future of Sustained Observations and Services", to be held in Bangkok, Thailand, 26-28 November 2013; and IOC WESTPAC's 9th International Scientific Symposium, 22-25 April 2014, Vietnam.

Discussion. Presentation 23.

Noted with relevance to IIOE-2.

Presentation 24. Peter Pissierssens (also presenting on behalf of Dicky Allison, Shannon Rauch and Ward Appeltans). Data accessibility for discovery and re-use.

This presentation proved to be a seminal contribution, providing detailed insight and suggestions on what had been considered and discussed as a critical issue for IIOE-2 (ie Data and Information Management) at past related meetings and through informal discussions and exchanges amongst stakeholders inter-sessionally.

This presentation represented the interests and relevancy of IOC's IODE (International Oceanographic Data and Information Exchange program), the USA's National Science Foundation funded BCO-DMO program (Biological and Chemical Oceanography Data Management Office), the Census of Marine Life's original OBIS program (Ocean Biogeographic Information System) and Australia's IMOS (Integrated Marine Observing System).

The over-riding messages from this presentation were fundamentally important in the sphere of IIOE-2 data and information management, with the messages focussing on ensuring that the data and information to flow from IIOE-2 are not only well curated, managed and quality assured, but that they result in maximal uptake and benefit to the IO constituents that IIOE-2 will set out to benefit.

To that end, PP strongly advocated for an explicit and dedicated emphasis to be assigned to data and information management. He further pointed to the need to have IIOE-2 connect to and take advantage of the range of available IODE data and information management mechanisms, and associated capacity building programs.

The following points were highlighted in the talk, in order to present and emphasise the models and existing frameworks potentially available to an IIOE-2 in respect to engaging or aligning with Data and Information management.

In respect to BCO-DMO per se

- BCO-DMO is a merging of the formerly independent Data Management Offices formed in support of the US JGOFS and US GLOBEC programs.
- BCO-DMO is funded by the U.S. National Science Foundation (NSF) to publish data from research projects funded by the Biological and Chemical Oceanography Sections and the Office of Polar Programs Antarctic Organisms & Ecosystems Program at NSF.
- BCO-DMO manages data from the CoML Census of Marine Zooplankton sub-program (2004-10) and also from the 1962-65 IIOE cruises (which are also within OBIS). Note was made that

OBIS is the world's largest open access, online data system concerning the diversity, distribution and abundance of marine species.

- BCO-DMO provides a geospatially text-based reference interrogation system to search, locate, access and visualise its data, complete with associated metadata descriptions of its data sets.
- Relevant web links were given as:
 - BCO-DMO: <http://www.bco-dmo.org>
 - CMarZ: <http://www.cmarz.org>
 - OBIS: <http://www.iobis.org>

In respect to OBIS per se:

- OBIS is a strategic alliance of hundreds of scientists and organisations who contribute data, information and expertise to OBIS.
- It comprises 22 OBIS Nodes from around the world with at least six being within the IO region and others nearby.
- Apart from the NW IO region, the IO shows a relative paucity of OBIS data on global comparison.

In respect to IODE per se.

- The IOC's IODE program (International Oceanographic Data and Information Exchange) was established in 1961 (www.iode.org), during the time of the original IIOE.
- IODE's purpose is to enhance marine research, exploitation and development, by facilitating the exchange of oceanographic data and information between participating Member States, and by meeting the needs of users for data and information products. Specifically, it works to:
 - Facilitate and promote the discovery, exchange of, and access to, marine data and information including metadata, products and information in real-time, near real time and delayed mode, through the use of international standards, and in compliance with the IOC Oceanographic Data Exchange Policy for the ocean research and observation community and other stakeholders;
 - Encourage the long term archival, preservation, documentation, management and related services of all marine data, data products, and information;
 - Develop or use existing best practices for the discovery, management, exchange of, and access to marine data and information, including international standards, quality control and appropriate information technology;
 - Assist Member States to acquire the necessary capacity to manage marine research and observation data and information and become partners in the IODE network;
 - Support international scientific and operational marine programmes, including the Framework for Ocean Observing for the benefit of a wide range of users.
- The IODE network includes national, regional and global scale components, as follows:
 - National: eg National Oceanographic Data Centres; Associate Data Units (since 2013); Marine Libraries (with IODE national coordinators for marine information management); and OBIS Nodes (since 2010);
 - Regional: Ocean Data and Information Network hubs (with IODE regional coordinators); and OBIS Nodes (since 2010); and
 - Global: World Data System (ICSU); World Data Centres for Oceanography.

IODE Associate Data Units were further explained.

- Projects, programs, institutions or organisations can join IODE as Associate Data Units (ADUs), and thereby derive the following benefits:
 - Receive information on, and contribute to, IODE standards and best practices related to ocean data management;
 - Be welcomed to participate in ocean data and information management training, organized within the framework of the IODE OceanTeacher programme;

- Receive assistance, upon request, from IODE, on matters related to ocean data management;
- Be invited, as observers, to participate in Sessions of the IODE Committee;
- Participate in IODE workshops and projects; and
- Share expertise with other ADUs and NODCs.

It was suggested that IIOE-2 could therefore establish an IIOE-2 ADU as a project under its own framework.

The IODE network of National Ocean Data Centres (NODCs) was overviewed, showing the ~ 80 countries that have NODCs, and noting that the IO is yet to enjoy complete coverage.

The issue of 'data sharing' was then addressed in the presentation, highlighting the IOC Data Policy (2003), which includes, but is not limited to the generic commitment of Member States providing timely, free and unrestricted access to all data, associated metadata and products generated under the auspices of IOC programmes.

- In this context, the role of the Ocean Data Portal (ODP) as a data/information sharing framework was detailed (<http://www.oceandataportal.org>), as one that links data systems and allows searching across the network, as a distributed system.

It was therefore suggested that the IIOE-2 and partners within IIOE-2 consider becoming nodes of the Ocean Data Portal.

The presentation then covered IODE and training (under the capacity building theme), and overviewed the IOC Project Office's activities in providing staff (trainers), courses and student facilities for training. This was linked to the OceanTeacher Global Academy (OTGA) initiative. The OTGA comprises aligned Regional Training Centres (RTCs) that can provide Capacity Building (CB) related training from sub-regional focal points.

It was therefore suggested, and generally agreed, that RTCs under the OTGA can have an important role in an IIOE-2, as part of the IIOE-2 CB aspirations.

Other relevant IODE activities were presented as 'OceanExpert' and 'OceanDocs' & 'Aquatic Commons' e-repositories (<http://www.oceanexpert.net>; <http://www.oceandocs.org>; <http://www.aquaticcommons.org>).

Finally, PP submitted that IIOE-2 would need to have a 'Data Management Plan' (DMP), and this was generally accepted in the context of IIOE-2 preparing a programme DMP and furthermore that each cruise, for example, would also have an aligned DMP.

e-MII of IMOS Australia

The presentation ended with information on IMOS Australia, through Director Tim Moltmann's submitted points on IIOE-2 and Data and Information management, with reference to IMOS's e-MII (e-Marine Information Infrastructure) data and information 'facility', as follows:

- IMOS is well advanced on the data front through the Australian Ocean Data Network (AODN) see <http://portal.aodn.org.au/aodn/>.
- IMOS portal infrastructure was stated to bench-mark well against US and European equivalents, and is being picked up and used by a growing community including New Zealand, the Southern Ocean Observing System, and potentially Pacific Islands GOOS.
- There is scope for IMOS/AODN to contribute to the IIOE-2, and IMOS will continue to work towards ensuring that new data collected by Australian researchers under IIOE-2 reaches AODN.
- Once IMOS understands fully the thematic and programmatic components being proposed under IIOE-2, it will be better placed and able to comment on what role IMOS could play.

Discussion. Presentation 23.

There was intermittent discussion on aspects of PP's presentation throughout his presentation, leading to a number of points of concurrence, as follows.

PP suggested, and it was generally accepted, that a sub-committee for Data and Information and Management be formed, to manage not only the data aspects of the IIOE-2 but also the 'information' that is to flow from the program, including the role of promoting data citation by researchers publishing papers based on IIOE-2 data.

Furthermore, PP suggested that the recommended specific Data and Information Management sub-committee include a collaborative link with the OceanTeacher Global Academy, an activity of IODE that runs from 2014-17 and under which a number of Regional Training Centres (RTCs) will be established in the IIOE-2 region (potentially including Kenya, Mozambique, South Africa, India, Malaysia, and possibly China). The RTCs will provide technical training (such as on data and information management) and can therefore contribute to IIOE-2 through relevant aligned training courses in the IO region.

It was generally accepted that the merit of IIOE-2 establishing an ADU project under its framework, was well worth considering, and that the proposed Data and Information Management sub-committee under IIOE-2 could provide the ideal vehicle for this to be considered and materialised.

It was further suggested that IIOE-2 partner institutions/countries could establish ADUs under IIOE-2 where no National Ocean Data Centre (NODC) exists (or where an existing NODC's cover is not sufficiently comprehensive).

It was suggested, and generally agreed, that the IIOE-2 and partners within IIOE-2 could respectively become nodes of the Ocean Data Portal.

It was suggested, and generally agreed, that RTCs under the OTGA can have an important role in an IIOE-2, as part of the IIOE-2's CB aspirations.

PP submitted that IIOE-2 would need to have a 'Data and Information Management Plan' (DMP), and this was generally accepted in the context of IIOE-2 preparing a programme DMP and furthermore that each cruise, for example, would also have an aligned DMP.

Following the presentation, WZ asked specifically how best to ensure Best Practice in IIOE-2 data and information management.

PP responded by referring participants to details of IODE components *per se* and related aspects covered in the presentation, and then to existing IODE related National QC practices already in place.

WZ asked if there were any IIOE-1 data available and accessible and also whether there were any existing documents addressing data management.

PP referred to the respective OBIS database and World Ocean Database for data access, and then suggested National electronic marine data and information management programs be referred to for data management documents (eg IMOS Australia).

Presentation 25. Zainal Arafin. Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia) - Research Centre for Oceanography (LIPI-RCO) 2015-20.

This talk outlined RCO's structure, facilities and research plans out to 2019, with a view to stimulating consideration of future cooperation under IIOE-2 out to 2020.

RCO has marine stations at P. Bari, Jakarta, Lombok, Ambon, Tual, Bitung, Ternate and Biak, comprising a complement of over 100 researchers, and with access to at least two major RVs (eg Baruna Jaya VII and VIII).

Current research involves:

- Coral reef management and rehabilitation;
- Aquaculture;
- Coastal and ocean health, through foci on:
 - Development of bio-indicators;
 - Bio-ecology of harmful Algal Blooms;
 - Bio-remediation for oil contaminated ecosystems.
- Climate change, through foci on:
 - Role of mangroves and seagrasses in carbon storage;
 - Ocean acidification (undertaken jointly with Tokyo Tech).
- Biodiversity studies at the margins of the Indonesian seas.

The 2015-20 'mid-term' research plan includes foci on:

- The sea and economic development for available natural resources;
- Marine bio-resources in the 'Coral Triangle Initiative (CTI) area.

Generally, the 2015-20 RCO-LIPI research foci connect the following themes in an integrated framework:

- Food sustainability;
- Aquaculture/biotechnology;
- Marine conservation;
- Marine biodiversity;
- Coast/ocean health;
- Anthropogenic activities and climate change.

Discussion. Presentation 25.

LB enquired on the two Indonesian RV's plans for the IO beyond EEZ waters.

ZA advised that the vessels planned to work in the EEZ after 2015, focusing off Sumatra.

ML enquired if RCO and other Indonesian marine-related agencies worked in collaboration under overlapping mission.

ZA indicated that there were operational interactions amongst the various agencies.

Presentation 26. Lynnath Beckley. Australia.

LB outlined the IMOS infrastructure network, a newly initiated Bio-Argo project, the WAMSI Kimberley program and information on potential voyages by the imminent new Australian RV Investigator. (*WAMSI = Western Australian Marine Science Institution*).

IMOS (www.imos.org.au) has two bio-physical reference stations (near coastal) off Ningaloo and Darwin, and cross shelf moorings off the Pilbara (3), Kimberley (3) and from shelf-to-shelf between Joseph Bonaparte Gulf and Timor Leste (6). It deploys gliders off Western Australia.

CSIRO Australia, NIO India and INCOIS India, with collaborative support from IOC PPO, recently succeeded in obtaining funding for the deployment of Bio-Argo floats (~8 floats) under the Australia-India Strategic Research Fund, and that project plans to collect information on: particle export, oxygen metabolism and sub-surface chlorophyll structure in the SE Indian Ocean.

WAMSI's Kimberly research program aims to improve the understanding of ecological processes in the Kimberley and their influence on marine biodiversity conservation, through the following areas:

- Physical oceanographic dynamics;
- Biogeochemical processes supporting productivity of coastal waters;
- Benthic community production & response to environmental forcing;
- Terrestrial-ocean linkages: role of rivers & estuaries in sustaining marine productivity;
- Climate modelling & Marine Strategy Evaluation (MSE) modelling;

- Historical reconstructions from the sediment record of water column variability as an influence on coral reefs.

The soon to be launched RV Investigator should be in place by 2014/15. Some of the projects that have been submitted to be undertaken from the RV in 2015/16, and relevant to IIOE-2 off WA, focus on:

- Faults, earthquakes, tsunami – identifying seismic hazard offshore of NW Australia;
- The IO's curved fracture zones – unravelling the 100 Ma plate tectonic reorganisation event;
- Exploring the relationship between temperature, CO₂, and sea level over the past 5 M yrs;
- Servicing the RAMA mooring off WA, including associated investigations of IO circulation, eastward flows, air-sea interactions, overturning cells, N fixation and the carbon cycle;
- A 'revisitation' of the IIOE '110°E' study lines/region (Beckley et al), but with a contemporary process-oriented ecological approach, using modern equipment, advanced technologies, contemporary questions, and attempting to:
 - Quantify changes in physical, chemical and biological properties of the water column;
 - Characterise bio-physical N sources and their ecological impacts;
 - Determine trophic relationships across N-fuelled primary production and zooplankton (including mesopelagic fish larvae).
 - Along a line from Fremantle to 110°E SW of WA, north along 110°E to Indonesia and back SSE-ward to Exmouth.
 - Including CTD profiling and plankton sampling, and microbial studies.
 - With scientific links to SIBER, IMBER, IOGOOS, EIOURI, IIOE-2 interests etc.

LB ended by pointing out that two ideal mid-ocean staging post bases exist and could well be considered in IIOE-2 operational planning, being Christmas and Cocos Islands, respectively. These have Australian Government presence (Parks Australia) and are sited as ideal locations for IO marine research, being in the ITF zone of influence (ie SEC).

Discussion. Presentation 26.

ND pointed out that he was aware of some scientific interest for comparison studies involving corals off NW Australia and similar latitudes in the E IO (eg off Madagascar).

RB emphasised the imperative of also considering marine biodiversity studies based from shore, as well as from ocean going platforms.

Presentation 27. Weidong Yu and Jun Sun. China.

WY outlined the essence of what could comprise key elements of an IIOE-2 Action Plan for China.

In terms of 'climate' as a driver of scientific objectives, the African-Asian-Australian Monsoon (AAAM), Indian Ocean Dipole Mode and ENSO were given as key foci.

Super cyclones associated with the Monsoon onset was also a key interest area.

The role of the IO on mega-droughts that occur in DJF in the Indo-Australian region, during JJA over N-NE Asia and during MAM (the so called 'long-rain' period) & ON (the so called 'short-rain' period) over NE Africa, were highlighted as high priority societally relevant areas of interest.

The role of the IO in influencing rain and water availability in the IO region as well as globally was highlighted, with links to agriculture.

Other areas highlighted included: fisheries research (with links to food security – eg perhaps focussing on the tuna source area in the Indonesian-Australian Basin); expansion of oxygen minimum zones; and dynamical coupled ocean-atmosphere linkages between E and W IO, at intra-seasonal and inter-annual time scales.

WY ended by overviewing the MOMSEI program cruise plans for the waters of the NE IO, off Thailand-Indonesia, and in the BoB, with relevance to upwelling areas in that overall domain.

MOMSEI = *Monsoon Onset Monitoring and its Social & Ecosystem Impacts*, a program supported by IOC WESTPAC, and closely linked to IOP and SIBER science objectives.

As a supplement to WY's presentation on China IIOE-2 relevant activities, Jun Sun (JS) presented an additional overview of 2010-13 National Natural Science Foundation of China (NSFC) cruises conducted in the IO and referred to a planned 2014 cruise. The cruises comprise multiple-institute (Chinese) collaboration and will address a number of integrated science objectives.

Discussion. Presentation 27.

Noted with relevance to IIOE-2.

Presentation 28. Iwao Ueki. Japan.

IU presented on Research Institute for Global Change (RIGC) / JAMSTEC plans for on-going and future observational research activities for the eastern tropical IO. Foci included:

- Attending to RAMA moorings (in the NE IO);
- The IOD in the NE IO off Sumatra (including based on RAMA observations), including near-coastal;
- Meso-scale eddy related upwelling, off Java;
- Ningaloo Nino dynamics, focussing offshore of the N-NW Australian shelf (ie within the Indonesian-Australian Basin area).

Discussion. Presentation 28.

Noted with relevance to IIOE-2.

Presentation 29. Mike Landry. USA.

ML reported on activities and related research (recent, current and prospective) that would fall within the spirit of an IIOE-2, in the following regions/categories:

- Bay of Bengal (see also: <http://shipsked.ucsd.edu/Schedules/2013/>)
 - Air-Sea Interactions Research Initiative (Office of Naval Research (ONR));
 - Leg 1 (Nov 2013: Pls J Farr, D Lucas, J McKinnon) focussed on sub-scale dynamics to resolve the vertical component of lateral N-S gradients in velocity, density, S, heat, optical properties through CDOM/Chlorophyll, and utilising wire-walker profilers, T chains, CTD-velocity, long-range gliders.
 - Leg 2 (Nov-Dec 2013: Pls J Farrar, E Shroyer) focussed on N-S variability, bio-optics, large scale marine mammal surveys, southern 'process' study and utilising gliders (including turbulence measurements) and drifters.
 - Collaborations and training under this initiative involved Notre Dame University, the Indian Ocean Marine Research Centre, Sri Lankan National Aquatic Research and Development Agency (NARA) and several local universities.
 - BoB Freshwater Effects on IO Monsoon (US Naval Research Laboratory (NRL));
 - Dec 2013-2015. Air-sea interactions and upper ocean processes, water exchanges, BoB and Arabian Sea inter-comparisons, radiating semi-diurnal tides from the Andaman Sea. The work involves experimentation and modelling, utilising six long-range mooring deployments (focussing on the Sri Lankan Dome), ADCPs, chi-pod sensors, and survey cruises with the RV Revelle (May-June 2014).
- Arabian Sea
 - Ongoing research;

- Lighthouse Ocean Research Initiative (LORI 1 & 2: PI S Di Marco). Sea of Oman research, involving cabled observatory, seismic investigations, currents, relevant to guiding ship traffic and tsunami warnings.
 - Post SE Monsoon research (PI S Smith; USA National Science Foundation (NSF) funded). Focussed on zooplankton sampling in the Masirah Island area (of SE Oman, facing the IO).
 - *Noctiluca* blooms (PI J Goes; NSF and NASA funded). Involves satellite algorithm development and research on environmental controls of *Noctiluca* blooms.
 - Collaboration with JAMSTEC. Comparing monsoon influences on ecosystem processes in the BoB and NW Pacific.
 - Pending/planned research;
 - NIO India collaboration (pending proposal). (PIs J Moffett, B Ward, W Naqvi). Central/western Arabian Sea - study of a 'hot spot' of nitrous oxide concentrations, the accumulation of nitrous oxide under hypoxic conditions, involving measurements of chemical parameters and key rate processes. Based on proposed NIO RV cruises (aboard a forthcoming RV), during 2014, 2015 and 2016, respectively.
 - PIs L Talley, S Riser, K Johnson. Planned. Deployment of ~20 Bio-Argo floats, to examine upwelling, OMZ and control of meridional SST gradient.
 - Another area of potential research (PIs D Rudnick, T Paluskiewicz) (ONR DRI). Research on the Somali Current, utilising gliders in conjunction with a complementary array of profiling floats to examine large scale seasonal and inter-annual circulation and stratification.
- Southern IO
 - Bio-Argo float deployments south of 30-35 deg S. A funded project (PIs L Talley, K Johnson, J Sarmiento and others). Deployment of 50 Bio-Argo floats, from South Africa to Australia, south of 30-35 deg S, planned for 2017-18, coincident with the I9S repeat hydrography line. Parameters to be measured: nitrate, O₂, pH, bio-optics. Supports general IO modelling efforts.
- Repeat hydrography
 - US Repeat Hydrography along WOCE sections. (PIs G Johnson, L Talley). There are plans to return to the IO this decade to re-run I8S, I9N, I6S, I5, to follow the last run which took place during 2007-09.
- International Ocean Discovery Program (IODP). (see also <http://iodp.tamu.edu/scienceops/expeditions.html>).
 - (PI S Clemens; IODP – USIO). Prospective IODP related surveys: seafloor sediments, geological features, paleo-climate, deep-sea life, geo-hazards, and planetary dynamics. The following targeted phenomena are proposed as foci of cruises:
 - Exp 353 Nov14- Jan 15 Indian Monsoon
 - Exp 354 Jan-Mar 2015 Bengal Fan
 - Exp 355 Mar-May 2015 Arabian Sea
 - Exp 356 Jul-Sep 2015 Indonesian Throughflow

Discussion. Presentation 29.

Noted with relevance to IIOE-2.

Presentation 30. Mike Roberts. South Africa.

MR presented an overview of ongoing and planned (South African) research projects in the SW IO, on behalf of South African groups: Oceans and Coasts of DEA; Agulhas Somali Current Large Marine Ecosystem (ASCLME) program (under the auspices of GEF/UNDP); African Coelacanth Ecosystem Program (ACEP) (under the auspices of NRF).

MR referred to a 2005-2010 review (under the auspices of ACEP II and ASCLME) of geographical areas that required priority ocean research, referring to 12 specific geographic focus areas, covering the W/SW IO. This led to a number of cruise related investigations throughout the 5 year period, involving a wide range of observing infrastructure operated and deployed from a number of RVs. The results of these many research projects are to be consolidated into papers (biological and physical) in a special edition of Deep Sea Research II (likely 2014).

MR referred to prospective research in the SW IO region, covering biological and physical research issues, referring to many publications which provide the foundation for future research (as can be found, for example, in Deep Sea Research II).

Highlights of MRs list of priorities covered:

- Observational (from RVs, satellites, and through robotics and moorings), analytical, theoretical and modelling studies.
- Eddy fields throughout the whole SW IO region will be a focus (along with associated studies of the eddy origins, water mass and biotic transport, BGC dynamics and interactions between the Agulhas Current and eddies).
- The Mascarene Plateau can be expected to receive relatively more attention in the 2015-20 period.
- The southern extension of the East Madagascar Current will be a priority area.
- So too, the Walters Shoal and Madagascar Ridge.
- New work may be focussed on the dynamics (bio-physical) associated with sea mounts in the southern areas of the SW IO.

In concluding, MR emphasised that:

- Present and near-future observational studies in the SWIO will be strongly driven by priorities and operational/research programs in LME programs and they will be multi-disciplinary;
- The W IO research community is very much still in a phase of discovering circulation features, dynamics and variability;
- Notwithstanding funding, strong emphasis will be assigned to biogeochemical coupling/productivity;
- There appear to be few WIO ocean-atmosphere coupling studies on the horizon, although these are important imperatives;
- IIOE-2 engagement for the W IO community will focus more on contemporarily relevant cruise paths, and less on straight repeats of surveys along original IIOE lines;
- One likely imminent priority, building on emerging research currently underway, will be to focus on the East African Coastal Current and the Somali Current.

Discussion. Presentation 30.

Noted with relevance to IIOE-2.

Presentation 31. Tore Stromme. Norway.

TS presented on behalf of Norway and FAO, providing an overview of the history of the EAF-Nansen project and plans for the next EAF-Nansen project phase (2016-20).

The original RV Dr Fridjof Nansen (Norway) began its work in the mid-1970s. A new Dr Fridjof Nansen came into operation in 1994. The next RV Dr Fridjof Nansen is to be built in 2014, to begin operations in 2016.

The general concept for past and future Dr Fridjof Nansen RVs is:

- Operate as a research vessel at disposal for developing nations, ambulating to be tasked and work around a wide area of operation;
- Operated from Norway with Norwegian crew and core scientific staff;
- In close cooperation with FAO, which would advise on operational areas;
- Uncoupled from Norwegian fishery interests, wearing the UN-flag as sign of neutrality;

- Operations co-funded by Norway and UN-organisations (initially UNDP and later GEF and partner countries).

The RV Fridjof Nansen RVs have operated principally in the W IO (including the Arabian Sea), with activities also around Sri Lanka, East BoB, Gulf of Thailand and in and around the waters of the Malay Peninsula and Sumatra.

A key societal driver of the Nansen's work has been the need to support fisheries through underpinning scientific understanding. Some of the research areas that have been facilitated by the Nansen's work include:

- Assessing pelagic fish resources by acoustic methods;
- Assessing demersal fish resources by statistical sampling with bottom trawl;
- General environmental monitoring;
- Benthic mapping (eg bathymetry, habitats such as corals);
- Multi-parameter water column profiling and sampling;
- Pelagic (including planktonic and benthic) sampling and on-board analyses;
- Epibenthic collection and sampling;
- Cetacean visual observations;
- Seabird observations;
- Underwater visualisations (eg video methods);

The EAF-Nansen project is now in a transition phase (2012-15), during which a new RV Fridjof Nansen is to be built and a program for the project to be developed (for 2016-20). In that context, the following related points, for interest in planning IIOE-2, were made:

- The next project phase will include objectives relating to setting baselines for monitoring climate change.
- The new RV Dr Fridjof Nansen will be ready for operations in time for the next phase of the EAF-Nansen project (2016-20).
- There will be scope for new partners to be included in the project (it is understood UNDP and IOC will be two such new partners).
- Demonstration surveys will be mounted during 2014/15 to attract new partners.
- A new program document is in preparation, to be ready by late 2015.
- The Norwegian Government and FAO are, in the context of the forthcoming new project phase, 'interested' in the IIOE-2, and in that context, TS submitted that:
 - The next phase of the EAF-Nansen project could play a leading role in the SW IO, in partnership with collaborating institutions and in respect to the IIOE-2.
 - EAF-Nansen surveys would have to be multi-disciplinary in nature and be doing work under an ecosystem approach theme, with respect to observations and related data acquisition and analyses.
 - A potential co-funding model, to harness the Nansen vessel in IIOE-2, would likely follow the same model as in the past, where the running costs would be provided at a rate of 30% (~\$10000 USD/day) by partner organisation(s) and 70% by the Norwegian Government, with this model expected to apply for the 2016-20 period. The \$10K may have to be increased to some extent to bring it up to date (for 2016-20) since the \$10K rate refers to an original 2005 setting.

Discussion. Presentation 31.

Noted with relevance to IIOE-2.

Presentation 32. Hermann Bange (and for Martin Visbeck). Germany.

On behalf of himself and MV, HB outlined recent projects undertaken in the past few years by German institutions in the W/SW IO (largely as discrete projects, essentially site specific and without region-wide and thematic inter-project integration).

HB then then moved on to advise that Germany was about to undertake multi-institutional discussions on a prospective German integrated IO marine/atmospheric study for the coming few years, in the context of an IIOE-2.

The recent and current (to 2014) projects that were presented are summarised as follows:

- SPACES (Science Partnerships for the Assessment of Complex Earth System Processes).
 - 2013; BMBF funded; RV Meteor; Port Louis to Walvis Bay transect (PI W Ekau); Cooperation and Capacity Building with South Africa and Namibia (PI M Visbeck).
- RHUM-RUM (Reunion Hotspot and Upper Mantle – Reunions Unterer Mantel).
 - 2013; France/Germany funding collaboration (RV Meteor and RV Marion Dufrense); La Reunion mantle plume, from crust to core; (PI K Sigloch).
- CARIMA (Controls of past monsoon variability in central Asia recorded in marine archives). Sub-project of the CAME project (Central Asia and Tibet: Monsoon Dynamics and Geoecosystems).
 - 2011-14; N-NW Arabian Sea; BMBF funded.
- MARUM (Centre for Marine Environmental Studies).
 - PI U Tubingen.
- BoB and South China Sea research.
- SPACES-SONNE (Training and Capacity Building in the SW IO).
 - July 2014; PI K Kruger, GEOMAR; pairing of African and German students, undertaking training at different training centres in the SW IO, covering meteorology, atmospheric physics and chemistry, physical oceanography, marine biogeochemistry, data analysis, student presentations and a final colloquium.
- OASIS (Organic very short-lived substrates and their air-sea exchange from the IO to the stratosphere).
- MARUM (Centre for Marine Environmental Studies).
 - July-August 2014; Male to Port Louis cruise. PIs K Kruger, B Quack, C Marandino; GEOMA

HB then made the point that there has been an identified need amongst oceanographic stakeholders in Germany for a transition now, considering also the IIOE-2, to an integrated German Indian Ocean study (with coupled ocean-atmosphere objectives). In respect to this, HB followed by advising that there is to be a DFG-Rundgesbrach (German Research Foundation (DFG) - Round Table Discussion (Rundgesbrach)) in January 2014, with a view to harnessing the German research community under the spirit of planning for integrated research relevant to an IIOE-2.

The Jan 2014 Rundgesbrach will follow the first that was held in Kiel (organised by HB, GEOMAR) on 18 Feb 2013.

The Jan 2014 DFG-Rundgesbrach has been titled:

- *Towards and Integrated German Indian Ocean Study 2015-2020: From the Seafloor to the Atmosphere.*

Proponents for the meeting are:

- Hermann Bange and Martin Visbeck.

The subject of the meeting will be:

- Discussing what is needed to understand the role of the IO system in the context of future changes in the Earth System and associated impacts of the coastal states;
- Explore how the German research community may want to contribute to IIOE-2.

The specific objectives to be explored are:

- Identification of the most relevant integrative science topics;

- Identifying specific objectives from the German research community in the international framework of the IIOE-2 initiative;
- Potential field campaigns using R/V Meteor and R/V Sonne in the IO;
- Prospect of a collaborative funding proposal.

The meeting invitation list derives from at least the following organisations (noting that > 30 participants are expected):

- GEOMAR (Kiel)
- U Hamburg
- MPI Meteorol. (Hamburg)
- ZMT (Bremen)
- MPI Marine Microbiology (Bremen)
- IOW (Warnemünde)
- IfT (Leipzig)
- MPI Chemistry (Mainz)
- U Heidelberg

A roadmap for this German initiative was presented, as follows:

- 1st planning meeting in Kiel on 18 Feb 2013 organized by HW Bange;
- Proposal "Towards an Integrated German IO Study 2015-2015" by HW Bange and M Visbeck, submitted to DFG 01 Nov. 2013;
- BMBF/CSIR proposal for Indo/German cooperation (workshops etc.), HW Bange/SWA Naqvi - deadline 01 Dec 2013;
- DFG Meeting 22/23 January 2014;
- April 2014 Implementation plan for Integrated German IO Study;
- June-August 2014: cruises SO234/2 and SO235;
- Sept. 2014 apply for R/V Meteor/Sonne ship time in 2016/2017;
- 2015-2020 Integrated German IO Study?

HB also provided information on the forthcoming EGU GA 27/4-2/5/14 Vienna, and Session BG3.3/OS3.3: Understanding the Indian Ocean Systems: Past, Present and Future. Conveners: HB et al). www.egu2014.eu.

HB ended by suggesting a number of key science themes that might be considered for the German initiative, such as:

- What is the past, present and future role of the IO in the Earth System?
- How do on-going environmental changes impact the marine ecosystem and biogeochemical cycles of the IO?
- Which natural and anthropogenic processes are controlling biological production and fish stocks of the IO?
- Which roles do sediments play for the marine ecosystem and biogeochemical cycles of the IO?
- What are the socio-economic consequences of the on-going environmental changes for the countries bordering the IO?
- What are the consequences of the loss of marine biodiversity and overfishing in the Indian Ocean?
- What are the potential contributions of the Indian Ocean to sustainable development for the coastal states and in the areas beyond national jurisdiction?

Presentation 32. Discussion.

Generally noted with relevance to IIOE-2.

MM suggested that the German initiative, if realised, might provide an opportunity for opportunistic deployments and operational support for IndOOS.

Nick D'Adamo and Raleigh Hood. Comments without PowerPoint presentations on behalf of UK and India, respectively.

RH reported that UK consideration and prospective related plans for IIOE-2 were to be prepared over the coming months.

ND reported that Indian colleagues (namely from INCOIS) referred the RG2 meeting to the discussions and related meeting record and Technical Report from RG1, as a relatively recent status report on India's interests and plans for IIOE-2. He further relayed the point that India had, since early 2013, established an Indian National Organising Committee for IIOE-2, comprising membership from a full suite of relevant agencies.

3 Identification of missing stakeholders and countries and how to engage them.

The meeting moved directly to the Day 2 15.15-16.00 session (*Identification of missing stakeholders and countries and how to engage them including strategies to motivate the formation of additional national planning committees*). This was agreed due to the preceding discussion essentially having adequately addressed the Day 2 14.00-15.00 sessions as part of the presentations and related discussions of the preceding presentations.

A précis of the plenary discussion on missing stakeholders/countries is given herewith:

Netherlands: MM will liaise with Will De Ruijter (IOP member).

France: GM will liaise with Jerome Vialard (IOP Co-Chair).

Flanders/Kenya link (RV link): PP to explore.

South Africa: MR will liaise with David Vousden (ASCLME and IRF Chair)

India: Considered already well engaged.

Indonesia: there is awareness that Indonesia has begun a process whereby national scale discussions on IIOE-2 have begun.

National IOC focal points. Participants were requested to report back to their own national IOC focal points with a view to advocating for their respective countries (through those focal points) to support IIOE-2 at the IOC level (noting the forthcoming IIOE-2 agenda item at the 47th Executive council meeting of IOC (1-4 July 2014)).

It was decided that a short 2 page summary of the RG2 meeting would be useful for the above advocacy purpose, along with a few slides providing the overview of the IIOE-2 planning results to date.

ND undertook to try to prepare the document, and make available his own PPT slides (with overview context).

Mauritius: RB undertook to advocate and work towards the creation of a Mauritius national committee for IIOE-2 and also to seek possible hosting for another RG meeting, focussed for SW IO stakeholders.

UK: ND to advise P Burkill (SCOR President, based in UK) and G Cowie (SIBER) on RG2 outcomes, with a view to catalysing advocacy for IIOE-2.

Australia: ND to report on IIOE-2 to the Australian Oceans Policy Science Advisory Group.

LB: to promote IIOE-2 through the forthcoming annual Australian Marine Sciences Association conference (July 2014, Canberra, Australia).

EOS: RH and MM undertook to write an EOS article on IIOE-2.

Saudi Arabia: RH to liaise with Xabier Irigoyen (who attended IIOE-2 RG1 in Hyderabad, May 2013).

Kuwait: RH to liaise with Faizal Al-Yamani (SIBER and IOCINDIO stakeholder).

Iran: ND to liaise with Vahid Chegini, Director, Iranian National Institute for Oceanography and Atmospheric Science.

Thailand: WZ to liaise with Somkiat Khokiattiwong, Phuket Marine Biological Centre.

Oman: Liaison via SIBER group: RH as a focal point.

PICES: WY advised that PICES conveys to the RG2 meeting, through WY, its support of IIOE-2.

Other countries: ND advised that all future formal IIOE-2 planning meetings would again involve communications to all IOC Member States (147) via standard IOC Circular Letter disseminations. Furthermore, the IOC Perth Program Office website provides a constantly updated publically accessible portal for IIOE-2 planning information.

4 Closing discussions and follow up

It was agreed during the final plenary discussion that all agenda items had been addressed, either explicitly or by way of embedded discussions throughout the various sessions.

Prof Adote Blivi (IOC Officer) emphasised that SW IO stakeholders could be better engaged in the IIOE-2 planning process. He submitted that every effort should be made to achieve engagement. In response, ND and RH undertook to be available and work towards a re-convening of a community of practice for that purpose, in the SW IO region, subject to the identification and commitment of a local host and sufficient interest from SW IO stakeholders to participate in such a meeting, noting that there is no obvious or likely source of funds to support the meeting or participation.

In response, RB indicated again that Mauritius, as one possible option, might be able to host another RG meeting, with specific focus for SW IO stakeholders, but that he would need to first check on Mauritius Government agreement and capacity to do so.

As one possible option, RB to explore Mauritius Government capacity to host a focus group meeting for IIOE-2 planning for SW IO stakeholders. RB will work with RH and ND, in liaison with Mika Odido (IOC AFRICA) on the regional interest and logistical feasibility of holding a focus group meeting in early 2014 to add to the planning process for IIOE-2. The specific objective would be to provide SW IO stakeholders with an added and final opportunity to contribute to the IIOE-2 planning process ahead of the 2014 IOC Executive Council meeting.

The meeting closed after summary comments by ND and RH, and closing comments from the local host WY.

5 Copy of Agenda

International Indian Ocean Expedition 50th Anniversary 2nd Reference Group Meeting, November 20-21, 2013, Qingdao, India

Co-Chairs: Nick D'Adamo (UNESCO/IOC Perth Programme Office (PPO)), Raleigh Hood (USA/UMD)

IOC Representatives: Peter Pissierssens (UNESCO/IOC Project Office for IODE, Oostende, Belgium), Wenxi Zhu (IOC WESTPAC Secretariat), Adote Blim Blivi (UNESCO/IOC Vice-Chairperson, Lome, Togo)

IOGOOS Representatives: Rezah Badal (Prime Minister's Office, Mauritius), Nick D'Adamo

IMBER Representative: Raleigh Hood

SIBER Representatives: Raleigh Hood, Lynnath Beckley (Australia/Murdoch University), Mike Roberts (South Africa/Dept Env. Affairs), Mike Landry (USA/SIO)

IOP/CLIVAR Representatives: Weidong Yu (China/FIO), Yukio Masumoto (Japan/JAMSTEC), Mike McPhaden (USA/NOAA), Ming Feng (Australia/CSIRO), Raleigh Hood (USA/UMD)

Local Host: Dr. Weidong Yu (China/FIO)

Sponsors: First Institute of Oceanography (China); UNESCO/IOC Perth Programme Office; IMBER; IOC WESTPAC

Participants: Hermann Bange (Germany/HCOR Kiel), Hui Liu (China/YSFRI), Gary Meyers (Australia/CSIRO Emeritus Professor), Yun Qiu (China, TIOSOA), Jun Sun (China, Tianjin U.), Jim Costopulos (USA/Global Oceans), Tore Stromme (Norway/IMR), Iwao Ueki (Japan/JAMSTEC), Cabell Davis (USA/WHOI), Rubao Ji (USA/WHOI), George Hickey (USA/Global Oceans), Su Mei Liu (China/Ocean U.), Gui Ling Zhang (China/Ocean U.), Jing Ling Ren (China/Ocean U.)

Day 1 (09:00 – 17:15)

- 09:00 – 09:30 *Welcome and Introductions* (**Nick D’Adamo** and Raleigh Hood)
- 09:30 – 09:45 *Welcome and Logistics* (**Weidong Yu**)
- 09:45 – 10:00 *Review of the meeting agenda and goals* (**Raleigh Hood** and Nick D’Adamo)
- 10:00 – 10:30 *Report from the first IIOE-2 Reference Group meeting* (**Raleigh Hood** and Nick D’Adamo)
- 10:30 – 10:45 *Morning Tea*
- 10:45 – 11:30 *Report on a proposed governance structure for IIOE-2 planning* (**Nick D’Adamo** and Raleigh Hood)
- 11:30 – 12:00 *Update on the Eastern Indian Ocean Upwelling Research Initiative (EIOURI) planning efforts* (**Yukio Masumoto** and Weidong Yu)
- 12:00 – 13:30 *Lunch*
- 13:30 – 14:30 *Summary of the overarching science and societal drivers considered to date for IIOE-2 from a physical oceanographic and atmospheric science perspective* (**Gary Meyers**, Mike McPhaden, Ming Feng, Mike Roberts, Rezah Badal, Yukio Masumoto, Weidong Yu)
- 14:30 – 15:30 *Summary of the overarching science and societal drivers considered to date for IIOE-2 from a biogeochemical and ecological science perspective* (**Raleigh Hood**, Jun Sun, Lynnath Beckley, Hermann Bange, Cabell Davis, Rubao Ji, Mike Landry, Tore Stromme, Sue Mei Liu)
- 15:30 – 15:45 *Afternoon Tea*

15:45 – 16:30 *Plenary discussion: Consolidation of current considerations on overarching science drivers for IIOE-2 - discussion and synthesis of ideas* (**Raleigh Hood** and Nick D'Adamo)

16:30 – 17:15 *Plenary discussion: Consolidation of current considerations on overarching societal drivers for IIOE-2 - discussion and synthesis of ideas* (**Nick D'Adamo** and Raleigh Hood)

19:15 - 22:15 *Group Dinner. All participants invited.*

Day 2 (08:30 – 13:30)

08:30 – 08:45 *Plan for day 2* (**Raleigh Hood** and Nick D'Adamo)

09:15 – 09:45 *Informing the IIOE-2 science and societal drivers in the context of the physical resources that can be mobilized through Global Oceans.* (**Jim Costopulos** and George Hickey)

08:45 – 09:15 *Planning for the IIOE-2: The IOC WESTPAC perspective* (**Wenxi Zhu**)

09:45 – 10:00 *Where are the data? Making oceanographic data from the IIOE-2 (and the Indian Ocean in general) accessible both to discovery and re-use with a spotlight on the availability of IIOE data.* (**Raleigh Hood** for Dicky Allison and Shannon Rauch, BCO-DMO, and Tim Moltman, IMOS)

10:00 – 10:15 *Assessment of ongoing and planned research activities as relevant to IIOE-2 in the Indian Ocean in the 2015 to 2020 time frame: China* (**Weidong Yu**, Hui Liu, Yun Qiu, Jun Sun, Su Mei Liu, Gui Ling Zhang, Jing Ling Ren)

10:15 – 10:30 *Assessment of ongoing and planned research activities as relevant to IIOE-2 in the Indian Ocean in the 2015 to 2020 time frame: Japan* (**Yukio Masumoto**, Iwao Ueki)

10:30 – 10:45 *Morning Tea*

10:45 – 11:00 *Assessment of ongoing and planned research activities as relevant to IIOE-2 in the Indian Ocean in the 2015 to 2020 time frame: USA*
(**Mike Landry**, Raleigh Hood, Mike McPhaden, Cabell Davis, Rubao Ji, Jim Costopulos, George Hickey)

11:00 – 11:15 *Assessment of ongoing and planned research activities as relevant to IIOE-2 in the Indian Ocean in the 2015 to 2020 time frame: UK*
(**Raleigh Hood** for Greg Cowie, Brian King and Peter Burkill)

11:15 – 11:30 *Assessment of ongoing and planned research activities as relevant to IIOE-2 in the Indian Ocean in the 2015 to 2020 time frame: Australia and Indonesia* (**Lynnath Beckley**, Ming Feng, Nick D'Adamo, Gary Meyers)

Day 2 Continued (11:30 - 17:00)

11:30 – 11:45 *Assessment of ongoing and planned research activities in the Indian Ocean as relevant to IIOE-2 in the 2015 to 2020 time frame: India*
(**Nick D'Adamo** for Wajih Naqvi, Satheesh Shenoi, Prasanna Kumar and M. Ravichandran)

11:45 – 12:00 *Assessment of ongoing and planned research activities as relevant to IIOE-2 in the Indian Ocean in the 2015 to 2020 time frame: South Africa and the Southwestern Indian Ocean* (**Mike Roberts**, Rezah Badal, Adote Blim Blivi)

12:00 – 13:30 *Lunch*

13:30 – 14:30 *Plenary discussion: Assessment of ongoing and planned research activities as relevant to IIOE-2 in the Indian Ocean in the 2015 to 2020 time frame, with the goal of embracing and organizing these activities as part of a larger coordinated 50th Anniversary research initiative.*
(**Raleigh Hood** and Nick D'Adamo)

- 14:30 – 15:00 *Drafting a table of known and prospective IIOE-2 ‘activities’ (planned cruises, new cruises, events, advocacy etc) (Nick D’Adamo and Raleigh Hood)*
- 15:00 – 15:15 *Afternoon Tea*
- 15:15 – 16:00 *Identification of missing stakeholders and countries and how to engage them including strategies to motivate the formation of additional national planning committees (Raleigh Hood and Nick D’Adamo)*
- 16:00 – 16:30 *Discussion of next steps including future meetings and finance and coordination with India, UK (and other?) national IIOE-2 committees. (Nick D’Adamo and Raleigh Hood)*
- 16:30 – 16:45 *Discussion of meeting report development (Nick D’Adamo and Raleigh Hood)*
- 16:45 – 17:00 *Closing remarks by Nick D’Adamo and Raleigh Hood, and any final reflections plenary*
- 17:00 *Adjourn*

Appendix 1

Consolidation of sections in this report that were shown in bold/italics, representing aspects of the discussions that constitute an action or key summary point agreed to in plenary.

Participants were asked (and agreed) to note the governance structure concept that evolved from IIOE-2 RG1 and to refine and add detail to it as a result of the meeting's presentations and related discussions over the next two days of deliberations.

It was generally agreed that IIOE-2 should continue to focus on the entire IO region, with effort needed to better engage W/NW IO constituents in the planning process.

The notion of holding a 'focus group' meeting for the W/SW IO was raised as a desirable follow-up to this workshop. RH and ND to work with RB to examine W/SW IO regional possibilities for such.

ND suggested the discussion on data provided motivation to ensure there is an explicit 'DATA/INFORMATION' theme in IIOE-2, linked to IODE. This notion was accepted and will be embedded in the revised governance structure for IIOE-2 (below).

In summary, the discussion pointed to the following explicit IIOE-2 aspects requiring their own focus (eg as themes or division or sub-committees in the governance) (some of these have of course already been raised in prior iterations of the IIOE-2 planning process, but are repeated here, for emphasis).

- *Knowledge Transfer (ie Capacity Building), where the science translates into societal benefit through training, education, mentoring, uptake etc.*
- *Data and Information Management (as above, with IODE in mind).*
- *Ecosystems: assessment/inventory, characterisation of key processes, including related dynamics.*
- *An IIOE-2 'Chapter/Theme' for and to engage organisational alliances (such as WIOMSA, AMSA, SANCOR etc), and similarly;*
- *An IIOE-2 'Chapter/Theme' for and to engage institutional alliances (high level, intergovernmental, such as IORA, COI, GOOS SC, LMEs etc).*
- *An IIOE-2 'Theme' (high level driver) relating to derivation of wealth from the ocean (Blue Economy).*

The EIOURI reports (referring respectively to physical and biogeochemical aspects) were well received and 'upwelling' as a key science theme (having agreed clear and important societal applications) was strongly supported for IIOE-2.

It was again confirmed and generally agreed that 'upwelling' become a unifying science theme (having high societal relevance) for IIOE-2, with the issue of examining and motivating interest and research on upwelling in the WIO to complement EIOURI emphasised.

It was generally agreed that one unifying theme for IIOE-2 should be along the lines of 'the IO's role in coupled ocean-atmosphere dynamics with reference to related extremes and hazards, with due reference to trends under climate change'.

WZ submitted that Sea Level Rise, in the context of climate change, be an important extreme to be considered. This was agreed.

The discussion generally converged on the agreed need to have 'marine extreme events' as one unifying theme for IIOE-2, with reference to the influence of a changing climate.

ND, GM and MM suggested, and it was agreed, that the stated priorities of WIO constituents pointed generically again to the unifying theme of 'the ocean's role in weather' as relevant to coastal and terrestrial productivity (eg fishing, agriculture) and safety (eg hazards – marine and land).

It was generally agreed that WIOMSA be invited to engage in IIOE-2, through the inclusion of a chapter/division for such alliances (that addresses knowledge transfer, from science to societal benefit/uptake) in the governance structure of IIOE-2.

It was agreed that the 'IOD characterisation, prediction/predictability and relevancy to marine and climatic extremes' should constitute a unifying theme for IIOE-2.

It was agreed that a unifying theme for IIOE-2 should cover the issue of 'changes in the IO and adjacent terrestrial environs since the IIOE of 1959-65'.

There was general agreement again on the need for IIOE-2 to have as a unifying theme 'the role of the IO on climate extremes'.

There was general discussion leading to agreement that IIOE-2 should have as a unifying theme an objective referring to 'sustainability of a Blue Economy in the IO'.

There was general discussion and agreement that the specification of the IIOE-2 science drivers can and should draw on the ecosystem and biogeochemical objectives inherent in the six high level themes of the SIBER program and the three of the LiCO program.

There was general agreement with all points raised in the Hermann Bange / Martin Visbeck talk, and the distillation of the key guiding points (some reinforcing existing points and some new) for designating IIOE-2 over-arching objectives in the areas of:

- **Improving the IO baseline inventory (bio-physical).**
- **IO wide ocean stressors – warming, de-oxygenation and acidification.**
- **Atmospheric pollution from haze clouds and aerosols, and impacts on the ocean.**
- **Coupled ocean-climatic hazards (including sea level rise).**
- **Characterising and responding to unsustainable natural resource exploitation.**
- **Characterising and responding to eutrophication.**
- **Characterising marine biodiversity and threats to it.**
- **Role of sediments derived from coastal sources, and impacts on IO ecosystems.**
- **Monsoon characterisation (current and under changing ocean-climate conditions).**

There was general agreement that the material presented by Cabell Davis on zooplankton/upwelling was compelling and note was made of its link to the EIOURI objectives. In this context, there was general agreement as to the designation of a science driver along the lines of: Effects of upwelling on zooplankton and links to higher trophic levels.

Raleigh Hood consolidated his summation of the preceding presentations on science and societal drivers into three generic sub-groups: Physical, BGC/Ecosystem and Societal. These were generally accepted as relevant to an IIOE-2.

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Physical Oceanography and Atmospheric Science Drivers:

- **Upwelling dynamics and variability.**
- **Monsoon variability and predictability.**

- *Extreme events.*
- *Climate variability and change.*

Biogeochemical and Ecosystem Science Drivers:

- *Ocean stressors (warming, de-oxygenation, acidification, eutrophication, atmospheric pollution).*
- *Biodiversity loss, changes in phenology and biogeography.*
- *The Indian Ocean's role in the global nitrogen cycle.*
- *Fisheries: recruitment, productivity and links to biogeochemistry and physics.*

Societal Drivers:

- *Food security and fisheries (commercial and artisanal, overfishing).*
- *Change in coastal environments (sea level rise, coastal erosion, loss of mangroves).*
- *Human impacts of climate change, extreme events and monsoon variability.*
- *Biodiversity loss and ecosystem preservation for tourism and fisheries.*

Nick D'Adamo presented a list of focus area themes that he distilled out of and/or interpreted from the presentations and related discussions (both during the sessions and throughout discussions during the breaks and in the margins of the agenda items), as follows. These were generally accepted as relevant to an IIOE-2.

- *In respect to SIBER's relevant themes: all of SIBER's themes are relevant to draw from, particularly under the motivation of understanding the IO's role in sustaining life (natural and anthropogenic), and BGC and ecosystem processes (6 themes to distill).*
- *In respect to IOP's relevant themes: as for SIBER, all of IOP's themes are relevant.*
- *Data & information management: a key area of priority, particularly in respect to IIOE-2 data/information curation, accessibility, longevity, utility for societal benefit. This emerged as a key area requiring a dedicated chapter/division in the IIOE-2 sub-committee structure, and links to IODE were seen as fundamentally important in this context.*
- *GOOS: IIOE-2 can and should have a major role in enhancing GOOS in the IO, and to this end a link between IIOE-2 and the GOOS SC is desirable and should be established. Again, the IIOE-2 governance framework can cater for this priority through an appropriate sub-committee structure.*
- *Revisit and examine W/SW IO relevancies and themes for IIOE-2 (possibly through a dedicated focused W/SW IO workshop).*
- *Create a specific Knowledge Transfer theme through an IIOE-2 sub-committee. This derives from the general and repeated references made at this and the RG1 meeting that an IIOE-2 with science pursuits in the absence of aligned, complementary and harmonised Capacity Building (CB) would be seen to be retrograde and narrow and lacking optimal societal relevance. Consistent input from stakeholders and institutional champions (eg IOC and IOGOOS related stakeholders and commentators) indicates that an IIOE-2 without appropriate and meaningful CB would receive much less support at/from their levels than otherwise would be afforded.*

- **Create a specific mechanism to engage and work with high level Governmental, institutional stakeholder associations, groups - again, through a dedicated sub-committee (engaging IORA, COI etc).**
- **Upwelling: examine the regional interest, feasibility and prospects for extending the strongly supported EIOURI research theme to the entire IO, either through a dedicated SWIOURI or an IO wide expansion of the EIOURI to an 'Indian' OURI (ie IOURI).**
- **IO's role in creating or modulating coupled ocean-atmosphere extreme weather hazards (eg monsoons, cyclones, droughts, storms, floods ...). The question arose: do we dedicate a theme to monsoons and address the 'others' in a dedicated complementary theme, or do we bring them all together under one umbrella theme? In this context we would note and refer to JCOMM as a key high level link.**
- **IO's role in creating or modulating extreme marine hazards (eg bleaching, other manifestations of temperature stress (recall Ningaloo Nino), acidification, transport of hazardous wastes [radiation, toxicants]), and again in this context we would note and refer to JCOMM as a key high level link.**
- **IO's role in global climate cycle / climate change understanding/predictability. This would involve an examination relating to the IO per se but also in relation to the IO as a conduit/conveyer of mass and energy through the spectrum of processes discussed at the workshop (and linking closely to motivations obtainable from IOP and SIBER science priorities).**
- **The Indian Ocean's physical dynamical and BGC links with its neighbouring oceans and marginal seas and the importance of the IO as a conduit/connector with these other bodies of water and as a major routing influencing global hydrological, BGC and climate cycles.**
 - **In this context we note the links that would be sensible to make with:**
 - **the Southern Ocean Observing System at the IO/SO interface and via boundary currents that propagate pole-ward (eg Agulhas and Leeuwin Currents) and counter-currents that propagate equatorward;**
 - **with the Pacific Ocean (noting the bio-physical transmitting characteristics of the ITF); and**
 - **with the Atlantic ocean (noting the Agulhas Leakage from the IO to the Atlantic).**
- **Improving bio-physical baselines/inventory. This is relevant in terms of both a pure scientific pursuit (the fundamental Voyage of Discovery motivation) and also in its relevancy to societal benefits. In this context, consideration would be given to biodiversity (bio-discovery, biotechnology, pharmaceuticals from the ocean), carbon, bathymetry, habitats, geological histories in substrate, corals etc, species discoveries. The priorities to be developed would draw importantly and heavily from the already well-reasoned and peer reviewed priorities that have emerged from the LiCO and CoML programs.**
- **IO and the BLUE ECONOMY: this was raised as a key driver for IO stakeholders, in terms of the potential value of an IIOE-2 in enhancing the prospects to derive wealth from the oceans under sustainable management framework. To that end, the improved scientific underpinning and knowledge transfer that could be gained from IIOE-2 adds to the compelling attractiveness of mounting an IIOE-2, appropriately framed. In this context, foci would include both improved and new observatories, process understanding, habitat inventories, facilitation of exploration, sustainable utilization of natural resources etc.**
- **Change in the IO: the prospect to examine changes in the IO's ecology and coupled climatic states is compelling. This would involve examining the results of the IIOE-1 of the 1959-65 period, through to the JGOFS, WOCE and IOP/SIBER eras and thence to what would emerge from an IIOE-2, as appropriate and possible.**

- **Linkages between atmospheric pollution/material sources and the IO's ecosystem, in term of both characterization of processes and inventories of the state of health of marine and coupled atmospheric systems.**

Nick D'Adamo presented a list of focus area themes that he distilled out of and/or interpreted from the presentations and related discussions (both during the sessions and throughout discussions during the breaks and in the margins of the agenda items), as follows. These were generally accepted as relevant to an IIOE-2.

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- *Linkages between atmospheric pollution/material sources and the IO's ecosystem, in term of both characterization of processes and inventories of the state of health of marine and coupled atmospheric systems.*

Governance

Nick D'Adamo interpreted the results of presentations and associated discussions in terms of how the evolving IIOE-2 programmatic framework, or governance framework, would now look. This was presented in terms of an organogram, but can be best presented herewith as follows. There was general acceptance in principle with maintaining this structure for further discussion under the IIOE-2 planning process:

- *Steerage through respective institutional and scientific entities (including IOC, SCOR, IOGOOS [linking with IOP, SIBER, IRF]).*
- *Guidance for the science and societal benefit areas of IIOE-2, and this might include:*
 - *Scientific Reference Group;*

- **Societal Benefit / Capacity Building / Knowledge Transfer Reference Group.**
- **The creation of specific operational components (perhaps to be referred to as thematic ‘divisions’ or ‘chapters’ or ‘sub-committees’) in order to provide foci for operational components and specific stakeholder categories of the IIOE-2, including:**
 - **Cruise coordination (planning, coordination, regular review, reporting, standardisation of methodologies, cross-cruise communications etc);**
 - **Special events (such as the Indian NIO 50th Anniversary celebration symposium, planned for 2015 [noting NIO’s birth in alignment with the original IIOE]);**
 - **Scientific symposia and conferences (such as IIOE-2 annual conferences, and related meetings);**
 - **Data and information management under the IODE framework (the legacy of longevity and utility of data and information and products/outcomes/outputs from IIOE-2);**
 - **High level institutional partnerships (eg IORA, COI, IOC Regional Subsidiary Bodies and Decentralised Offices, AMCOMET, AMESD, LMEs etc);**
 - **Capacity Building (education, in-situ – such as on-board training on cruises, ‘laboratories/universities of the sea’), CB workshops, up-skilling, mentorship, studentships, exchange programs, utilisation of the IIOE-2 data in CB;**
 - **Communication & Outreach (building a constituency, dissemination of the results, engaging the broader community);**
 - **Knowledge Transfer (translating science into policy, management, applied utility, including the Blue Economy theme);**
 - **National IIOE-2 Committees (coordinated national approaches to IIOE-2 engagement, inter-committee integration);**
 - **Research initiatives (eg EIOURI, LOCO);**
 - **Scientific association partners (eg WIOMSA; AMSA; GEOTRACES, CORDIO, IMOS Australia, SANCOR, integration with UNESCO Category 2 and RSB training centres and similar entities (eg ITCOcean India)).**
- **Secretariat support, with this being regarded as a critical underpinning necessity for a successful IIOE-2.**
 - **The overall model emerging included a regional operational base, for example as has been provided so far through the IOC Perth Programme Office, working collaboratively with what hopefully would be the formation of sub-regional operational foci, and under the overall auspices of global coordination through the IOC HQ Secretariat via something akin to say an IIOE-2 Secretariat ‘Project Office’.**
 - **The IOTWS, GOOS SC and SOOS coordination models were noted as potential case studies from which to draw experience from in this regard.**

Mike Landry provided his high level summation (which was generally accepted as relevant to IIOE-2) of some of the key points to have arisen out of the preceding presentations on science and societal drivers:

Compelling physical questions:

- **Upwelling circulation & transport mechanisms (eg eddies).**
- **IOD initiation and variability.**
- **Climate sensitivities.**

Biogeochemical linkages:

- **Nutrient sources and fluxes.**
- **Biological transformations of nutrient signals.**
- **Production processes, process-based experiments.**
- **Food web pathways and trophic transfer efficiencies.**

PP suggested, and it was generally accepted, that a sub-committee for Data and Information and Management be formed, to manage not only the data aspects of the IIOE-2 but also the 'information' that is to flow from the program, including the role of promoting data citation by researchers publishing papers based on IIOE-2 data.

Furthermore, PP suggested that the recommended specific Data and Information Management sub-committee include a collaborative link with the OceanTeacher Global Academy, an activity of IODE that runs from 2014-17 and under which a number of Regional Training Centres (RTCs) will be established in the IIOE-2 region (potentially including Kenya, Mozambique, South Africa, India, Malaysia, and possibly China). The RTCs will provide technical training (such as on data and information management) and can therefore contribute to IIOE-2 through relevant aligned training courses in the IO region.

It was generally accepted that the merit of IIOE-2 establishing an ADU project under its framework, was well worth considering, and that the proposed Data and Information Management sub-committee under IIOE-2 could provide the ideal vehicle for this to be considered and materialised.

It was further suggested that IIOE-2 partner institutions/countries could establish ADUs under IIOE-2 where no National Ocean Data Centre (NODC) exists (or where an existing NODC's cover is not sufficiently comprehensive).

It was suggested, and generally agreed, that the IIOE-2 and partners within IIOE-2 could respectively become nodes of the Ocean Data Portal.

It was suggested, and generally agreed, that RTCs under the OTGA can have an important role in an IIOE-2, as part of the IIOE-2's CB aspirations.

PP submitted that IIOE-2 would need to have a 'Data and Information Management Plan' (DMP), and this was generally accepted in the context of IIOE-2 preparing a programme DMP and furthermore that each cruise, for example, would also have an aligned DMP.

National IOC focal points. Participants were requested to report back to their own national IOC focal points with a view to advocating for their respective countries (through those focal points) to support IIOE-2 at the IOC level (noting the forthcoming IIOE-2 agenda item at the 47th Executive council meeting of IOC (1-4 July 2014)).

It was decided that a short 2 page summary of the RG2 meeting would be useful for the above advocacy purpose, along with a few slides providing the overview of the IIOE-2 planning results to date.

ND undertook to try to prepare the document, and make available his own PPT slides (with overview context).

Mauritius: RB undertook to advocate and work towards the creation of a Mauritius national committee for IIOE-2 and also to seek possible hosting for another RG meeting, focussed for SW IO stakeholders.

As one possible option, RB to explore Mauritius Government capacity to host a focus group meeting for IIOE-2 planning for SW IO stakeholders. RB will work with RH and ND, in liaison with Mika Odido (IOC AFRICA) on the regional interest and logistical feasibility of holding a focus group meeting in early 2014 to add to the planning process for IIOE-2. The specific objective would be to provide SW IO stakeholders with an added and final opportunity to contribute to the IIOE-2 planning process ahead of the 2014 IOC Executive Council meeting.