Bay of Bengal Large Marine Ecosystem Project

BOBLME Oceanographic Working Group Meeting. Perth, Australia • 15 July, 2010.

BOBLME-2010-Ecology-05

The BOBLME Project is funded principally by the Global Environment Facility (GEF), Norway, the Swedish International Development Cooperation Agency, the Food and Agriculture Organization of the United Nations (FAO), and the National Oceanic and Atmospheric Administration of the USA. FAO is the executing agency.

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For bibliographic purposes, please reference this publication as:

BOBLME (2010) BOBLME Oceanographic Working Group Meeting. Perth, Australia. 15 July, 2010. BOBLME-2010-Ecology-05.

Part 1:

Report on the
Regional BOBLME Oceanography Workshop
(Held in conjunction with the Meetings of IOGOOS
and associated project groups)
(56 pages)

Part 2:

IOGOOS Workshop and 7th Annual meeting (IOGOSS VII)
July 12-16 2010, Perth, Western Australia
(68 pages)

Regional BOBLME Oceanography Workshop

(held in conjunction with the Meetings of IOGOOS and associated project groups)

15 July 2010 (Thursday) 1100-1730 hrs

Citigate Hotel, Perth, Western Australia

Report

By

Dr. V. Sampath
Consultant, BOBLME

Report on the
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1. Opening of the meeting

Dr. Rudolf Hermes, Chief Technical Advisor, BOLME, FAORAP, Bangkok, opened the meeting by welcoming the representatives of the BOBLME Member countries to the Regional BOBLME Oceanography Workshop which is being held in conjunction with the IOGOOS-7 meeting. He was confident that their participation in the IOGOOS meeting over the past three days would have given them an opportunity to upgrade their knowledge on the oceanographic processes affecting the Indian Ocean and exposure to the various programmes and projects that are being implemented under the auspices of IOGOOS and associated project groups.

A list of participants is at Annexure-1.

2. Adoption of the Agenda

The Provisional Agenda drawn up for the meeting was adopted unanimously (Annexure-2).

A list of Abbreviations and acronyms is at Annexure-3**.**

3. Oceanography and large scale dynamic processes affecting the Bay of Bengal Large Marine Ecosystem (BOBLME) - Presentation of Overview by Experts from the Member countries

3.1 Bangladesh

Dr. Zahedur Rahman Chowdhury, Bangladesh, presented the "Review of the Oceanography of the coastal waters of Bangladesh". The coastline of Bangladesh is 710 km, with an area of 1, 40,860 km² within the EEZ and 64,440 km² area within the continental shelf. There are more limitations than opportunities in so far as the coastal resources and the coastal zone of Bangladesh are concerned. The limitations include:

- Conflicts with maritime boundaries, particularly between Bangladesh and Myanmar,
- Impact of climate change and climate refugee including the displacement of people, coastal erosion, frequent floods resulted as a result of frequent high velocity cyclonic storms,
- Sea level rise, resulting in coastal inundation and destruction of movable and immovable properties,
- Absence of ocean monitoring system, and
- Policy not focused at National level.

The opportunities for monitoring coastal and open sea oceanography lie in

- Remote Sensing,
- Open source data,
- Operational Navy ships,
- National Oceanographic Research Institute (NORI) in pipeline, which is proposed to be set up in the next 3-5 years.
- The major extreme events like the cyclones give ample opportunities for studying the impact of land-sea interaction and the oceanographic and dynamic physical processes in the BoB on these extreme events.

Bangladesh has a comprehensive oceanography education programme in the undergraduate and post-graduate levels for creation of requisite trained human resources for undertaking oceanographic studies in the BoB.

Physical Oceanography of Bangladesh coast

Weather patterns are governed by the monsoons - the southwest and the northeast monsoon. The effect of local winds appears to be more important to the marine biota, especially in terms of existing stress, than the broad scale wind systems. The Northward maximum wind speed is recorded in June-July and the Southward maximum wind speed during December/January. The wind speed is minimal during March/October.

Reversing current pattern is observed in the Bangladesh waters. During the spring time the currents flow clockwise and in the autumn anti-clockwise. These current systems have profound influence on the seasons in Bangladesh.

The sea surface temperature along the Bangladesh coast and the open waters is in the range of about 22.8 – 32.9°C. No significant study has yet been conducted on the nutrients and productivity aspects of the BoB in the Bangladesh coast. The chlorophyll-a content varies from 0.19 to 12.62 μg/1. The primary productivity of the Bay is very high during northeast monsoon, 0.15-1.45 g C/m^2/day.

Intensity of the cyclones has been increasing, particularly in the months of May-June every year. The cyclone return period has become shorter.

There is a drastic change in the meteorological parameters. The coastal low lying areas are exposed to repeated natural calamities such as cyclones, torrential rains and floods including inundation of coastal areas by sea water. Storm surge during spring tide results in severe damage and destruction to coastal ecosystem and properties.

A National Land Use Policy was adopted by Bangladesh in the year 2002. The prime objective of this Policy is to restrict the conversion of agricultural land for other purposes. It addresses the issues related to land management for maximizing the return from its use. It does not address the physical damages to the lands due to natural causes such as erosion, accretion, sedimentation, etc.

Bangladesh has adopted a Coastal Zone Policy in the year 2005, which aims at mainstreaming coastal zone management, strategic planning and programme development. Emphasis is laid on land zoning in conjunction with the land use policy. However, the main lacuna in the policy is that it does not address sea-level rise related issues along the coastline.

In spite of the fact that these policies are in place, there is no functional work plan, because of which these policies are yet to be implemented in reality.

Conclusions

While concluding the presentation the following major issues were flagged by Dr. Chowdhury.

- A few policies concerning exclusively the marine environment have been framed.
- Environmental policy 1991 and 1992 focused attention on marine environment.
- Regular oceanographic survey should be conducted.
- Ocean observing system should be implemented immediately, by becoming a member of IOGOOS, IndOOS and ARGO network.
- Research on Oceanography should be prioritized at national level.

- Observation, understanding and proper prediction of oceanic phenomena could attribute to sustainable resource management and minimize colossal damage due to climate change.

A copy of the power point presentation made by Dr. Chowdhury is at Annexure-4. For further details refer to "National Report of Bangladesh on Sustainable Management of the Bay of Bengal Large Marine Ecosystem" by Dr. Md. M. Maruf Hossain, January 2004 (www.fao.org, www.boblme.org).

3.2 India

Dr. V. Sampath, BOBLME Consultant (Oceanography) presented an "Overview of the Oceanography and Large-scale Dynamic Processes affecting the Bay of Bengal" bordering India.

The east coast of India is 4,645 km long (about 56% of India's 8118 km coastline), covering the states of West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Pondicherry and Andaman & Nicobar Islands and has a population of over 225 million. The Indian states situated along BoB have a continental shelf area of 153,000 km². The EEZ area of 1.16 million km² in the region forms 57% of the total EEZ of the country. Of this, the EEZ around Andaman & Nicobar Islands is 51%.

Climatically the area falls under severe monsoon influence and is impacted by cyclones, tidal surge and inland flooding resulting in environmental refugees. A number of perennial east flowing rivers of India (such as Ganga, Brahmaputra, Meghna, Mahanadi, Godavari, Krishna, Cauvery and other minor rivers) bring in large quantum of freshwater inflows (1.38×10^9 ton yr^{-1}) and about 1.5 billion tons of suspended sediment (BOBPS, 2006), which influence the dynamics of the ecosystem.

The annual surface water temperature varies within a narrow range of 27 to 29°C. In general, the shelf waters along the bay are nearly isothermal. The thermocline, whenever found, is usually below 50-55 m and, in some cases, even below 100 to 125 m.

The average values of salinity in the Bay of Bengal (BoB) are rather low and range between 30 and 34. The low salinity in the bay is mainly due to the diluting effects of the large volume of river discharge. Values and variations of temperature, salinity and density depend on monsoonal regime.

Sedimentation load in the large rivers entering the BoB reduces carrying capacity. Bengal Fan sediments render ocean floor bathymetry virtually featureless. In the northern end of Bay, bathymetry is shallow. Bathymetry over the central Bay is relatively flat and the average depth is around 3000 m.

Rossby waves excited by remotely-forced Kelvin waves play a significant role in the variability of circulation in BoB. Prominent feature of circulation is that it is the East India Coastal Current reverses direction twice a year. The East Indian Current flows

northward from Jan-Oct and the southwestward flowing current – the East Indian Winter Jet, during Sept-Dec.

Tides and waves

Around South Indian coast the tides are micro-tidal with a range of around 1 m. Tides up to 2 m are observed in the Andaman Sea. Along the northeast coast the tides are macro-tidal with 4m in Bengal coast. Surface Waves are typical fine-scale continental shelf waves propagating shoreward from shelf break. Internal wave activity along continental shelf is observed almost in all the seasons. Earthquake generated waves in the year 1762 and Tsunamis in the years 1881, 1883, 1941 & 2004 affected the east coast of India.

Ocean – atmosphere interface

- Net heat flux shows very small variation, from 0 to 30Watt m^{-2}.
- Major regions of moisture sink with net negative moisture flux divergence were observed.

Upwelling

Annual scale equatorial upwelling is absent, but it is prevalent during the NE monsoon. River discharge in the north overwhelms the signatures of upwelling.

Climate variability

- Increasing trend of break monsoon due to changes in large scale monsoon circulation and vertically integrated moisture transport, point to role of SST warming trend (0.015°C/yr).
- Dipole Mode in Indian Ocean has shown that ocean-atmosphere coupling dominantly determines inter-annual variability of climate.

Eddies are ubiquitous influencing the hydrography and circulation, thermohaline characteristics and altering the nutrient as well as chlorophyll pigment concentrations in the Bay. Northern Coastal Eddy is robust and occurs every year, for about 5 months.

Productivity

BOBLME is a moderately productive ecosystem. Average primary productivity of BoB is 1.47 – 9.1 mgC/m³/day and zooplankton bio-productivity is 0.18 – 0.80 ml x m^{-3}. In spite of nutrient input, reduced downward penetration of solar radiation due to large quantities of sediment brought by adjoining rivers, limits productivity in the northern BoB.

Surface and integrated chlorophyll-*a* during summer monsoon is 4-5 times lesser than that in Arabian Sea while integrated primary productivity is about 8 times less. Chlorophyll pigment concentration declined over 1997 to 2007 in line with global trends. Surface chlorophyll value of the BoB ranges between 0.14 and 0.28 mg/m³.

There were few occurrences of Harmful Algal Blooms (HAB) reported after cyclones and related churning effects. Blooms of *Noctiluca scintillans, Trichodesmium* and *Cheatoceros* with associated fish mortality were reported from Gulf of Mannar.

Relation to chemical & biological oceanography & pollution

71 major industries and 110 ancillary industries discharge nearly 2.62 million m^3/day liquid wastes and about 19,830 tonnes solid wastes per day. Untreated industrial, urban and municipal wastes result in eutrophication and hypoxia leading to a decrease in marine flora and fauna and contamination of sediments with heavy metals, particularly in Tamil Nadu and Andhra Pradesh (Ramachandran, 1991).

Recent major oceanographic surveys, programmes & data inventories

- Marine geophysical surveys were conducted over 31,000 line km for delineation of outer limits of continental shelf.
- Deep Swath Bathymetric Surveys in Indian EEZ.
- Biogeochemistry and hydrodynamics of Tropical Indian Ocean.
- Water quality monitoring (Coastal Ocean Monitoring And Prediction System programme - COMAPS) in 82 points (18 in BoB).
- Atmospheric Science, Information & Services: Monsoon prediction.
- Development of 'Integrated *in situ* data and information system' and its integration with existing data base.
- Generation of metadata from moored buoys in OceanSITES format.
- Ocean Data Management and Dissemination.
- Global and Regional Climate Change.
- Climate Monitoring and Climate Information Services.
- Abundance and distribution of fish eggs and larvae in the up-welled waters.

National Programmes - oceanographic surveys, monitoring & prediction

- A long-term time-series current measurements programme established by deploying current meter moorings. CTD moorings have been deployed at 24 stations in BoB.
- Bay of Bengal Monsoon Experiment (BOBMEX) - air–sea interaction and intra-seasonal oscillations during summer monsoon.
- BOBPS; SATCORE; INDOMOD; Indian Ocean Forecast System (INDOFOS); NDBP; ARGO; COMAPS; Delineation of Outer Limits of Continental Shelf; Assessment of marine living resources in Indian EEZ; Swath Bathymetry; HAB; Physical and biogeochemical dynamics; Climate change/variability; Shoreline changes; Sediment transport – some major national programs being implemented.
- Regular oceanographic surveys using ORV Sagar Kanya, FORV Sagar Sampada, Sagar Nidhi, CRVs, NIO & GSI's research vessels.
- Ship board equipment, moorings, remote sensing data, GIS, Portable CTD, Current meters, AWS, Tide gauges, etc., are being used.

- Ocean Information Bank in INCOIS.
- Selected coastal universities/academic institutions offer regular undergraduate and PG courses in marine sciences including oceanography, coastal processes, etc.
- National R&D Institutions/Labs build capacity through training and awareness at various levels.

International, Regional, Global Programs, Regional Coordination & Partnerships

- IOGOOS Secretariat at INCOIS, Hyderabad.
- Major initiatives include Indian Ocean observations for climate, data & information management, capacity building, keystone ecosystems project, shoreline change monitoring project, prawn project, etc.
- IndOOS addresses observations on role of Indian Ocean in climate system and its predictability. RAMA, ARGO, SOOP/XBT lines, Drifting Buoys, etc., are used in generating data and data products. India is a Member in IOP and the data portal for Indian Ocean data is maintained by INCOIS.
- Data Buoy Cooperation Panel (DBCP) is a joint body of WMO and IOC for coordinating use of data buoys to observe atmospheric and oceanographic conditions. NIOT Scientist is the Vice-Chair for Asia and it is represented by Scientists from NIOT, NIO, INCOIS, NAL, etc.
- Argo project is implemented by INCOIS. Out of 175 floats deployed by India, 79 are active. INCOIS is the Regional Data Centre for Indian Ocean.
- India provides 60 day/yr ship time for implementing RAMA mooring programme. In Bay of Bengal, 3 RAMA moorings have been deployed and are maintained from the year 2007.
- Remote Sensing data provide inputs for coastal land use, shoreline changes, SST, currents, biological productivity (Ocean Colour), shallow water bathymetry and benthic cover.
- Recently a number of training and awareness programmes were conducted by INCOIS and NIO. Some of them are: INHO Multi-beam Training Course - Goa, during March 2008; Leadership Development Workshop - Hyderabad, May 2008; Argo User's Workshop – Hyderabad, July 2008; Tsunami Modelling and Inundation Mapping Training Course - Hyderabad, Oct - Nov 2008; and Second Multi-beam Training Course - Goa, April 2009.

Institutional arrangements & mechanisms for oceanographic survey, data gathering, storage and analysis

- Ministry of Earth Sciences (MoES): Matters relating to Ocean, meteorology, seismology, marine environment; HRD; international collaboration and cooperation; laws and regulatory
- Ministry of Agriculture (MoA): R&D in fisheries, fisheries education, international cooperation, fishing and fisheries.
- Ministry of Environment & Forests (MoEn&F): Environment and ecology of coastal waters excluding high sea environment.

- Ministry of External Affairs (MEA): Matters relating to UNCLOS & International Sea Bed Authority (ISBA).
- NIO under CSIR: Oceanographic research and survey.
- National Institutes such as NCAOR, NIOT, CMLRE, ICMAM-PD, IMD, NCMRWF, IITM (all under MoES), GSI, NHD, ONGC, Fishery Research Institutes such as FSI, CMFRI, etc., carry out oceanographic surveys, supported by National Research Laboratories (NIO, RRL, NGRI, NPOL, NEERI, NRB), ISRO, NRSC, SAC, CPCB, DST, SOI, CESS, selected Academic institutions, Universities, IISC and a few IITs with faculty and facility for oceanographic research.
- INCOIS Ocean Information Bank - serves as National Oceanographic Data Centre of India and a National repository of marine data.
- Autonomous institutions & field labs under MoES; NIO under CSIR act as regional R&D and training centres.
- A world class training programme in Earth System Sciences and Climate being put in place.

Gaps

- There is no proper mechanism for monitoring pollution at point and non-point sources and lack of scientific information for managing and reducing pollution.
- Lack of long-term time-series multi-disciplinary observations both in coastal and deep-sea regions to understand various processes with fine resolution.
- Oceanographic data are lying scattered in different agencies/organisations.
- Studies to understand influence of seasonally reversing monsoon winds on variability of water characteristics and circulation in BoB part of Indian Ocean are very limited.
- Atmospheric episodes leading to considerable damage in coastal regions, yet to be forecasted with sufficient accuracy.
- Reliable data on nutrient, bio-geochemistry, chlorophyll and other biological characteristics from the BoB are elusive.
- Participatory approach in ICZM and ecosystem management is yet to receive adequate attention.
- Most of the Acts, Rules & Regulations are yet to be enforced for want of adequate field level mechanism.
- Capacity building needs (staff training): Virtual lack of trained manpower in physical, chemical and geological oceanography.

Recommendations for priority actions and measures required

National

- Unifying the efforts and creating a repository of oceanographic data.
- Essential parameters (waves, tides, currents and sediment characteristics) should be monitored using satellite imageries and impact models should be generated for prediction of shoreline changes.

- More emphasis should be given for comprehensive oceanographic survey of BoB.

Regional/Sub-regional

- Abatement and elimination of adverse impacts of land-based sources of pollution.
- Incorporation of observations for bio-geochemical parameters to enhance interdisciplinary research in Indian Ocean sector.
- A new satellite with a pay load to measure surface salinity distribution in Indian Ocean which plays important role in climate system of surrounding regions, should be launched.
- Programmes for understanding changes in coastal zones at regional scale with respect to global climate change should be taken up.

BOBLME Level

- Agreed sea water quality standards should be developed for areas beyond territorial waters, which are transboundary in nature.
- Awareness creation among coastal community on various aspects relating to CZM to be given adequate emphasis.
- Combating accidental oil spills in high seas including studies on impact of oil rigs on Bay ecosystem.
- Information, education and capacity building should be addressed through integrated training programmes. Training in oceanography should be institutionalised by creating a world class facility.

Summary of trans-boundary oceanographic issues and concerns

- Land based sources of pollution is a major threat to entire coastal and marine ecosystem.
- Measures taken to prevent erosion/ accretion are not fruitful due to lack of proper monitoring and understanding of the coastal processes.
- Integrating satellite derived data in sediment transport and shoreline change prediction models and ecosystem modelling.
- Sheer quantities and content of suspended materials and nutrients entering BoB, affect coastal ecosystem health and pose public health risk.
- Strengthening institutional infrastructure for information exchange.
- Use of satellite communication system on a regional basis for oceanographic studies.
- Preparation of compendium of regional oceanographic information on important aspects such as permissible levels of pollutants, policies, legal framework, regulations, etc.
- Strengthening and improving scientific publications and journals in oceanography.
- Training of oceanographers in specific disciplines and specializations.

- Determination of carbon associated elemental fluxes in coastal areas which are potential contributors to land-ocean interaction, with a view to improve predictive capability of variability of coastal zones due to climate change.

Conclusions

- Past decades have seen major emphasis on west coast of India (Arabian Sea) than BoB.
- An analysis of present status of oceanographic studies and dynamic processes affecting BoB reveal the absence of a comprehensive and coordinated long-term interdisciplinary approach to the entire issue.
- Emphasis therefore to be on long-term comprehensive oceanographic studies covering all major physical, chemical, biological and geological aspects and climate variability/change at national/sub-regional/regional levels.
- Top priority to be given for human resource development through capacity building in oceanography in the region. A regional level state-of-the-art training facility – need of the hour.
- More active participation of BOBLME countries in the international, regional and global programmes on oceanography.
- Creation of an oceanographic data bank at national/sub-regional/regional and BOBLME level for exchange of information.

Detailed power point presentation made by Dr. Sampath is at Annexure-5. For additional information please consult "India National Report on the Status and Development Potential of the Coastal and Marine Environment of the East Coast of India and its Living Resources" by V. Sampath, November 2003. (www.fao.org, www.boblme.org).

3.3 Indonesia

Dr. Syamsul Rizal made a presentation on "Modelling of general circulation in the Andaman Sea and Malacca Strait".

The Andaman Sea is located along the north-eastern side of the Indian Ocean between the Malay Peninsula at the east and the Andaman - Nicobar Islands chain at the west. The Andaman and Nicobar Islands are volcanic in origin. As a result the water depth in this region changes rapidly from over 3000-4000 metres in the Indian Ocean to approximately 200 metres in the area around the islands, returning to deeper than 2500 metres in the centre of the Andaman Sea.

During the SW monsoon, the winds move from the south-west to the north-east. Strong winds between June and September lead to maximum rainfall over most parts of the Indian subcontinent. During the NE monsoon, the winds move from the north to the south-west.

West Coast of Sumatra shows the presence of a pronounced thermocline between 100 and 125 m. Above the thermocline the mixed layer is rather homogeneous, with

temperatures of 28-29°C throughout. Maximum SST for both NE and SW monsoon periods occur in the Malacca Strait and the Indian Ocean near Sumatra Island. Salinity is low at about 33 psu, which can be explained by the circulation pattern.

During NE Monsoon, the surface water masses enter the Andaman Sea along a narrow band close southerly of Cape Negrais. These water masses move to the south and leave the Andaman Sea in the wide area between south of the Andaman Islands and Sumatra. Parallel to Andaman Island in the Indian Ocean a southward current is shown.

A second surface water mass enters the Andaman Sea from the north-east side of the Malacca Strait. It spreads to the borderline between Thailand and Myanmar.

An anticlockwise gyre is located north of Sumatra between the island Weh and Lhokseumawe. This gyre blocks the outflow of the Malacca Strait over a part of its whole breadth.

In the Malacca Strait the surface flows always north-westward to the Andaman Sea for both, SW and NE monsoon, since the sea surface elevation in the south-east domain is always higher than that in the Andaman Sea both for the SW and NE monsoon.

Overview of recent major oceanographic surveys, programmes and data inventories

Several oceanographic surveys have been done, especially by Badan Pengkajian dan Penerapan Teknologi (BPPT), Jakarta, Indonesia. They were done before and after tsunami.

National Programme - Oceanographic Survey, Monitoring and Prediction System

BPPT as a coordinator has deployed some buoys for monitoring tsunami in the western part of Sumatra. Bakosurtanal has also installed some tide gauges in Indonesian waters for coastal observations. BPPT, LIPI and DKP have oceanographic research vessels and related tools for conducting oceanographic surveys. There are several Institutions namely DKP, BPPT, LIPI and BMKG involved in ocean data collection and dissemination.

Oceanography education programmes

In Sumatra there are several oceanographic institutions, i.e. Syiah Kuala University in Banda Aceh, Riau University in Riau, Bung Hatta University in Padang, West Sumatera, Sriwijaya University in South Sumatera, which offer courses on marine sciences including oceanography.

Public awareness activities, outreach, impact generation

In several coastal cities in Sumatra, especially in west part of Sumatra, Tsunami early warning system has been built. Especially in Banda Aceh, the Tsunami Museum and laboratory have been established for creating awareness among the coastal community.

Implementation of International, Regional or Global Programs on Oceanography, Regional Coordination and Partnerships

For implementing international and regional programmes partnership must be established between the Indonesian institutions and the international/regional bodies. With this partnership, many advantages can be gained, especially for the university institutions.

Institutional arrangements and mechanisms for oceanographic survey, data gathering, storage and analysis (existing policy frameworks and supporting legislations)

Institutional arrangement and mechanisms for oceanographic survey etc., exist. For better coordination in implementation of oceanographic survey and related programmes there is a need for meaningful collaboration with the regional organizations like IOGOOS and its associated project initiatives.

Gaps

Many surveys have been carried out in the BOBLME area by other agencies/organisations. However, the data that has been gathered are not being shared with others.

The policies and legislation on the use of oceanographic data in the country are not clear.

Capacity building needs (staff training)

As a new institution in Indonesia, there is a need for building capacity among the faculty members on oceanography through training and exposure visits.

Access to satellite and related products / means

We still need the information on these products.

Recommendations for priority actions and measures required

At national level, we must have a proper mechanism for getting the information/data. The activities of DKP, BPPT, LIPI and BMKG and Universities should be coordinated, not only in surveys but also in data processing and (if possible) in publications.

Regional/Sub-regional/BOBLME level

The mechanism and arrangement for exchange of information/data should be established.

Summary of trans-boundary oceanographic issues and concerns

Many activities (surveys, data processing, etc) have been carried out in the Indonesian coastal and marine waters. However, the information available is very little.

Conclusions

- Surface current distribution in the Andaman Sea and the northern part of the Malacca Strait changes seasonally, depending on the two different monsoon situations.
- The good agreement of the general circulation pattern from Wyrtki (1961) with the simulation results confirms Wyrtki's work.
- The temperature vertical cross sections are in good agreement with those observed by Keller and Richards (1967).
- There are vertical gradients of temperature in the Malacca Strait with surface values of 29°C for temperature and bottom values of 19°C.
- The mechanism and arrangement on how to exchange the information is still not clear.
- The coordination at all levels, whether it has been established or not, is not clear. This is a very important issue, which needs to be addressed.
- In Indonesia, only the Institutions like DKP, BPPT, LIPI and BMKG are involved in oceanographic survey. Universities in Indonesia that have no ship and not enough funding should also be involved in survey, data processing and publications.

Recommendations

- The model results should be validated with the help of up-to-date field level measurements and remote sensing data.

A copy of the power point presentation made by Dr. Riaz, is at Annexure-6. Additional information may be obtained from the "Indonesia BOBLME National Report" by Dr. IR. Sri Hartiningsih Purnomohadi, November 2003 (www.fao.org, www.boblme.org).

3.4 Malaysia

Malaysia was not represented in the Workshop. Details of the state of marine environment and its resources in the BOBLME bordering Malaysia could be found in the "National Report of Malaysia on the Formulation of a Transboundary Diagnostic Analysis and Preliminary Framework of a Strategic Action Programme for the Bay of Bengal" (www.fao.org, www.boblme.org).

3.5 Maldives

Maldives is a nation of small reef islands located in the Indian Ocean, stretched over an area of 90,000 square kilometres, 900 kilometres south west of Sri Lanka, stretching along 73° East Longitude from about 8° North to 1° South. The archipelago consists of 26 natural atolls with about 1200 islands. Of these, 202 islands are inhabited, with a population of 270,000 (2000 census). Maldives does not have a continental shelf. Maximum depth of the open ocean along Maldives is 5000 m. In the channels and the lagoons the maximum depth is around 50-60 m.

Being a linear string of atolls set in the Indian Ocean, strong latitudinal gradients/variations in some environmental and morphological characteristics are evident, some of which are given below:

- Strength of the monsoonal reversal increase to the north.
- Incidence of severe tropical storms increase to the north.
- Significant wave height increase to the north.
- Primary productivity increase in the north.
- Net solar radiation increase slightly to the north.
- Surface salinity is greatly affected by incursions of water from the BoB, but tends to increase in the north.
- Levels of DO at 100m to 200m increase to the south.
- Eddy energy (a measure of probability of meso-scale eddy occurrence) increase to the south.
- No water flow in the southern atolls.

Climate

Two distinct seasons affect the Maldives, the westerly (*Hulhagu*) between May and November, and the easterly (*Iruvai*) from December to March. The westerly season generally has the strongest winds and stormy weather.

There is a seasonal reversal in winds, currents and wave direction having an impact on the ecosystem and its resources. These dynamics cause morphodynamic changes on many islands. Reversal of monsoons is an important factor in the area. Upwelling is observed in the near-shore areas. In the absence of storms, wind is the most important process-driving factor affecting throughout the archipelago. Monthly average rainfall ranges between 50 mm and 230 mm, with the minimum in the month of February and maximum in the month of May.

Waves and tides

There is no time-series observation on tides in the Maldives. There is, however, a semi-diurnal mixed tide, with a maximum range of 1.2m. The meteorological tides show a normal distribution with no significant seiche activity.

Inside the atoll, wave climate is often governed by locally generated waves of five seconds or less; and significant wave heights outside the atoll for wind-waves are about 1.6m to 2.0m for swells. The highest waves occur between June and August, when wave heights are commonly over 2m high (and reach a maximum height of 4.2m). By comparison wave heights are generally less than 2m during the period November to May.

Primary Productivity

There is no time-series data/information on primary productivity. Harmful Algal Blooms (HAB) recorded for 3 days in July 2007 and in December 2007 in some of the islands led to extensive fish kills.

Oceanographic surveys

An oceanographic survey was conducted in a Research Cruise of RV Sonne during Dec 1997 – Jan 1998 involving the Institut für Meereskunde of the University of Hamburg as part of the International World Ocean Circulation Experiment (WOCE).

Another oceanographic expedition viz. TARA Expedition has been commissioned during September 2009 for a period of 3 years. A multi-disciplinary team of scientists from several countries is participating in this expedition. The major objectives of this expedition are:

- Mapping the distribution of the phyto/zoo plankton species.
- Survey and study of coral reef ecosystems.
- Using state-of-the-art real-time imaging techniques for cell sorting and photographing.
- Collection of data on the physical aspects of the oceans.

Implementation of International, Regional or Global Programmes

- Not been active in the regional programmes relating to IOC.
- Limited or no capacity; not been able to benefit form the large number of capacity building activities going on in the region.
- Member of IOCINDIO.
- Member of the IOGOOS; Department of Meteorology is the focal point.
- COASTMAP – Initiative formed following the tsunami.

Gaps in Knowledge that are of immediate relevance

- Lack of understanding on coastal hydrodynamics
  - Seasonal and regional variation in primary productivity.
  - Possible link between primary productivity and distribution and abundance of live bait resources.
  - Effect of atoll geomorphology on the productivity and retention within the atoll basin.

- Waves and current around the coastal areas
  - Reef health and resilience.
  - Reef connectivity.

Institutional Arrangements

- Marine Research Centre under the Ministry of Fisheries & Agriculture is mandated to undertake research in fisheries and marine resources plus coral reefs.
- Environmental Protection Agency and Dept. of Meteorology under the Ministry of Housing and Environment is in charge of implementation of environmental

regulations and research on environment; and operational meteorology. It also coordinates the collection of tide gauge data.

- Maldives College of Higher Education under the Ministry of Education/Dept. of Higher Education is proposed to be transformed into Maldives University.

Recommendations

- National
  - Revisit the mandates of the related institutions (EPA, MRC, Dept. of Meteorology) to redefine the activities relating to the physical and biological oceanography.
  - Implement a strategic human resources capacity building in physical and biological oceanography.
  - Increase Maldives' participation in the regional (IOC related) activities.

- Regional / Sub Regional / BOBLME Level
  - Engage in IOGOOS activities relevant to BoB region
    - SIBER / IRF activities.

The detailed presentation made by Dr. Adam is at Annexure-7. For further details please refer to the Maldives National Report titled "Sustainable Management of the Bay of Bengal Large Marine Ecosystem (BOBLME)". 2004 (www.fao.org, www.boblme.org).

3.6 Myanmar

Dr. Chit Kyaw, Assistant Director, DMH, Myanmar while making a presentation on "Ocean-Atmosphere Interaction Effect on Monsoon during 2002" – a paper on the Myanmar-India Joint Oceanographic Research cruise in the Bay of Bengal (ORV Sagar Kanya cruise No. SK 175) conducted during 15 April – 28 May 2002, informed that other than this short-term oceanographic survey no other coordinated effort has so far been made to study the oceanography in the Myanmar coast.

The paper gives information on the observations made and the data collected during this cruise, particularly the ocean-atmosphere interaction prior to the onset of the south-west monsoon including the rainfall pattern and cyclonic storms. SST (Sea Surface Temperature), Q (heat budget), (d) conductivity, S (salinity) and sea water current of sub-surface layer (about 200 m depths) are mainly governed by the monsoon conditions.

A summary of the observations made and the results thereof, presented by Dr. Chit Kyaw, is as under:

- Along-shore wind at 94°E (zonal wind) was causing weak upwelling till 10th May, but it strengthened thereafter. At 12°N and 13°N, the along-shore wind (meridional wind) was upwelling favourably till 10th May, but swung around thereafter to favour

downwelling. These changes in the local winds are reflected in the CTD observations. Andaman Sea being a small basin responds rapidly to changes in wind pattern.

- Downwelling, and therefore a poleward geostrophic coastal current, is evident in the temperature, salinity, and density fields at both 12°N and 13°N. The net current is a combination of both geostrophic and Ekman flow as evidenced by the eastward movement of surface drifters that were deployed in the central Andaman Sea after 15th May as part of the Ocean Observing System programme of NIO, Goa, India.
- SST of the isothermal surface layer of the Andaman Sea decreased from about 32 °C at 94°E, 14°N on 7th May to less than 30°C at 96.5°E, 12°N on 14th May, and the depth of the isothermal layer increased owing to wind-forced mixing from less than 20m to about 40m. The consistent change seen in the winds and SST across the basin in satellite-derived estimates suggests that this observed deepening of the surface layer was a basin-wide phenomenon.
- The seasonally reversing hydrography and circulation that is typical to the monsoon-forced north Indian Ocean, including the Andaman Sea, implies that similar surveys covering the other seasons in the annual cycle are required to map and understand the variability.
- Given the large number of atmospheric disturbances that form in this basin and its rich fisheries, it is important to understand the physical oceanography of this basin. The data collected during this cruise can help plan better future physical oceanography programmes in the region.

Conclusions

- SST is directed to govern the ocean-atmosphere interaction processes.
- Heat budget of sub-surface layer of BoB is primary source of these interactions.
- Heat transport from solar radiation is a major cause.
- Vertical ocean currents are due to upwelling and downwelling by the heat budget of ocean and wind-pressure system over the sea surface.
- Upwelling is one of the causes for perturbation of cyclonic activities and onset phase of monsoon during pre -monsoon period.
- Strong interaction between ocean and atmosphere favours early onset of south-west monsoon.

Recommendations

- More comprehensive surveys covering all the seasons in the annual cycle are required to map and understand the variability in ocean parameters and the dynamic processes affecting the BoB along Myanmar coast.
- Given the large number of atmospheric disturbances that form in this basin and its impact on the rich fishery resources, it is important to understand the physical oceanography of this basin. The data collected during this cruise can help plan better future physical oceanography programmes in the region.
- Capacity building in related fields, particularly through training in oceanography and further studies, is an essential requirement.

- Evolving basic principles for operational implementation of BOBLME project, needs to be given adequate importance.
- Exchange of data/information on current activities, among the BOBLME member countries.

A copy of the presentation made by Dr. Chit Kyaw is at Annexure-8. For detailed information on the Oceanography and large scale dynamic processes of Bay of Bengal abutting Myanmar could be seen in the "National Report of Myanmar on the Sustainable Management of the Bay of Bengal Large Marine Ecosystem (BOBLME), by Dr. Myint Pe, 2004 (www.fao.org, www.boblme.org).

3.7 Sri Lanka

A presentation entitled "Oceanographic Studies – Sri Lanka" was made by Dr. K. Arulananthan, NARA, Sri Lanka.

The oceanographic projects around Sri Lanka include:

- Monitoring of thermocline variation and internal waves (appear to be having a significant impact on the mixed layer depth of the BoB).
- Monitoring of upwelling.
- Sea level monitoring – impacts of climate change on sea level.
- Potential fishing zone forecasting.
- Coastal Ocean processes (comprehensive biological, physical, and chemical studies) of coastal water bodies.
- Ocean observations and maintenance of data – around` Sri Lankan waters.
- Numerical modeling of coastal waters.
- Heat budget studies (currently limited to coastal water bodies).
- Whale observations - towards a sanctuary.

Recommendations

- Ocean state forecasting (extreme events, long term trends)
  – *Marine Weather buoy*
- Palk strait flow
  - *Sub surface buoy*
- Coastal currents & hydrographic properties
  - *Deploy instruments to record*
- Date base management
  - *Software & training*
- Internal waves in BoB and heat budget of north Indian Ocean
  - *Software & training*
- *In situ* monitoring station – chlorophyll-a, temperature and salinity
  - *instrumentation*

- Numerical modeling on ocean processes around Sri Lanka (climate, sediment process & oil spill)
  - *Software & training*

A copy of the power point presentation made by Dr. Arulananthan, is at Anenxure-9. For further reading please see "National Report of Sri Lanka on the Formulation of a Transboundary Diagnostic Analysis and Strategic Action Plan for the Bay of Bengal Large Marine Ecosystem Programme" by Leslie Joseph, 2004. (www.fao.org, www.boblme.org).

3.8 Thailand

Dr. Tachanat Bhatrasataponkul of Ocean-Atmosphere System Research Laboratory (OASIS), Thailand, presented an "Overview of the Andaman Sea". Recently two major oceanographic surveys (short-term) have been conducted viz.

- Morphodynamic and Slope Stability of Andaman Sea Shelf (MASS) (Anond Snidvongs, Chulalongkorn University).

- Ocean Reef Coupling in the Andaman Sea (ORCAS) (Somkiat Khokiatiwong, Phuket Marine Biological Center).

Other than these two major surveys, no long-term comprehensive oceanographic survey has so far been carried out in the area.

During the Morphodynamic and Slope Stability of Andaman Sea Shelf (MASS) survey, several submarine morphologic systems such as sea mounts, mud volcanoes, and mudstone outcrops along the slope at depths between 500–2,000 m, could be identified.

Results from subsurface buoy of ADCP and temperature logger (deployed for studying the ocean reef coupling in the Andaman Sea) showed a strong signal of internal wave at more than 60 m depth. On the west coast of Similan Island the internal waves were observed at 150 m depth. The internal waves make nutrients available in the photic zone thereby increasing the primary productivity. Low concentration of nutrients (silicate, nitrate and phosphate) was observed in warm reef waters. The concentration of nutrients peaks in cold waters from internal waves. The cooler the water, the higher is the concentration of nutrients.

The sea is influenced by semi-diurnal tides of approximately 3 m in spring and 1 m at neap tide. The water circulation is tidally dominated by a major flow in a northeasterly direction.

During the northeast monsoon, the surface and subsurface flows in the near shore areas appear to move northwards at a speed of 2-4 cm/sec, while during the southwest monsoon, the surface flow moves southwards at a speed of 5-8 cm/sec, gliding over the

counter surface flow northwards of 2-5 cm/sec. During southwest monsoon period, the pycnocline depth increases and in the north-east monsoon season, it decreases.

Large scale ocean variabilities in the BoB include:

- Seasonal variations - *Water Circulation, Monsoon Dynamics,*
- Intraseasonal variability - *Madden Julian Oscillation (MJO), Oceanic Instability, and Tropical Planetary Waves (Kelvin & Rossby Waves),*
- Interannual variability - *El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD),*
- Decadal and longer time-scale variability - *Pacific Decadal Oscillation (PDO), Decadal Modulation of IOD, Cross Equatorial Cell, Sea Surface Temperature (SST) Trends, …*
- Inter-basin exchanges - *Indonesian Throughflow, Deep Overturning Circulation,*

A copy of the presentation made by Dr. Tachanat is at Annexure-10. For further studies please refer to the "Country Report for BOBLME Programme: Thailand" by Kungwan Juntarashote, 2004. (www.fao.org, www.boblme.org).

4. Plenary Session - Discussion

The following major issues emerged during the "Plenary Session – Discussion" on the presentations made by the experts from the 7 BOBLME member countries (excluding Malaysia):

- The transboundary issues and concerns among some of the BOBLME countries, which have not been spelt out by them in the presentation need to be identified and made available for preparation of the detailed Work Plan.
- The participants should send additional inputs for preparation of the Workshop report –in the template for country overview of oceanography and large scale dynamic processes affecting BOBLME, within a week of their return to their respective work place.
- For undertaking comprehensive ocean observation programmes, linkages between BOBLME and its Member countries or their joining IOGOOS as associate or full-time member(s) is very much essential.
- Some of the BOBLME members need adequate resources to become IOGOOS members and infrastructure support to take up comprehensive long-term oceanographic surveys.
- There is a need for creating a repository of oceanographic data in the region for exchange between the BOBLME member countries.
- Capacity building through need based training in oceanography, for effective participation of the BOBLME member countries' personnel in various project activities of IOGOOS and associated project initiatives, is an essential requirement. Training on global ocean models, remote sensing, fish pathology/toxicology etc., are of interest to some of the member countries. The

existing training opportunities, where-ever they are should be made use of including IOC, WESTPAC – China, INCOIS, NIO, etc.

- There are a number of IOGOOS initiatives such as Ocean Forecasting and Modeling, ChloroGIN, Shoreline change/management, biogeochemistry, etc., under the associated project initiatives of IOGOOS such as IndOOS, IOP, SIBER, etc.
- There is a need for calibration of the oceanographic methods and data generated in the BOBLME member countries. National Coordinators of BOBLME Project to give a checklist of the parameters and the training needs.
- BOBLME member countries could coordinate/interact with IODE, INCOIS and NIO for ocean data analysis, collation, exchange, training, etc., through the medium of IOGOOS.

5. Summing up/closure of the meeting

Dr. Rudolf Hermes while summing up the day's proceedings sought the opinion/views of the participants on the BOBLME Workshop and the IOGOOS meetings.

Dr. Z.R. Chowdhury of Bangladesh indicated that there had been a long felt desire of his country to join GOOS/IOGOOS and after participating in the IOGOOS meet at Perth, Bangladesh is eager to become a Member of IOGOOS. He opined that the joint meeting of BOBLME with IOGOOS meet, gave a lot of insight in remote sensing, modeling, etc., and it would help in Bangladesh joining the global network of ocean observation and information system and the BOBLME to have a connection with the Indian Ocean Family through IOGOOS.

Dr. Tachanat Bhatrasataponkul of Thailand was of the view that this joint meet of BOBLME representatives with IOGOOS members had given a very good opportunity to have an exposure to cross cutting issues at national and international level for cooperation in the area of oceanographic research and development in the BOBLME region.

Dr. Syamsul Rizal, Indonesia, thanked FAO/BOBLME for giving him the opportunity to participate in the joint meet of BOBLME and IOGOOS, which will be very useful, particularly for his country on ocean forecasting and modeling, using the Australian BLUElink programme or other models. He looked forward for better cooperation between the members of BOBLME/IOGOOS and his institution in carrying out the above task.

Dr. Chit Kyaw, Myanmar, opined that he got a lot of knowledge and exposure to various activities of IOGOOS and the oceanographic programmes carried out in other BOBLME member countries. Ocean forecasting is a very interesting subject. For him participation in the BOBLME workshop will be very useful particularly in the area of exchange/sharing of information with other members on oceanographic survey methodologies and data analysis, interpretation, etc.

Dr. Rudolf, CTA, BOBLME Project observed that the joint workshop/meeting of BOBLME with IOGOOS has opened up the opportunities to have synergy with the activities of IOGOOS by linking up BOBLME with IOGOOS. This will also give an excellent opportunity for the BOBLME member countries to broaden their knowledge through capacity building in the form of training and exchange of information in various disciplines of oceanography.

Dr. Sampath, Consultant, BOBLME, thanked FAO and BOBLME Project Secretariat, for giving him an opportunity to serve as a Consultant for the Workshop, which has given him an opportunity to interact with the participants from IOGOOS member countries in general and the BOBLME countries in particular on the various aspects of ocean observation and information services and better understanding of how best most of these activities could be appropriately linked with BOBLME programmes on Oceanography and dynamic processes in the Bay of Bengal; and the opportunities for better cooperation between the member countries of IOGOOS and BOBLME for developing and implementing meaningful national, regional and international cooperative programmes in oceanography.

Dr. Arulananthan, Sri Lanka, observed that BOBLME should look at regional scale and national level oceanography and capacity building as compared to IOGOOS which focuses on large scale international level linkages for ocean observation and capacity building. A synergy between IOGOOS and BOBLME will help us to grow together. Sri Lanka could not keep pace in oceanographic research with other countries which have progressed fast. Sri Lanka looks at near-shore processes than off-shore processes. There is vast knowledge and data base in the Indian Ocean under the ambit of IOGOOS and through our participation in the joint IOGOOS-BOBLME meeting we got a lot of exposure on the state of Indian Ocean and the processes that impact its environment and resources and it has given an opportunity to understand what we should do in the Bay of Bengal coast adjoining our countries.

Dr. Somkiat Khokiattiwong of Phuket Marine Biological Center, Thailand, who was a special invitee for the Workshop commended the efforts of FAO/BOBLME in organizing the joint workshop of BOBLME with IOGOOS-7 meeting. He was happy to note that the BOBLME project has now taken off. There is an enormous amount of data/information on Indian Ocean under the IOGOOS, IndOOS, IOP, etc., which will help the BOBLME member countries to work closely with one another and move faster in their efforts to understand the interaction of oceanographic parameters and the dynamic processes affecting the LME. There are a number of latest technological tools and models to execute oceanographic survey/research and to validate the results. There was a lot to learn through the interaction with the IOGOOS members during the past 4 days, which will help in taking up and implementing national and regional level programmes in oceanography in the BOBLME.

Dr. Rudolf Hermes declared the meeting closed.

6. IOGOOS and its relevance to BOBLME Oceanography

Indian Ocean Global Ocean Observing System (IOGOOS)

Indian Ocean Global Ocean Observing System (IOGOOS) involves a number of initiatives and projects, which bring benefit to its constituents in the Indian Ocean rim and islands including those in the BOBLME Region. Some of those established or under active development include the following themes:

- Keystone ecosystem mapping and monitoring of indicators of ecosystem health in coastal habitats;
- Shoreline change monitoring;
- Capacity Development in writing proposals for funding, and training for leadership in marine science/management;
- Remote sensing for environmental protection, conservation and natural resource management, including:

    - SAFARI = Societal Applications in Fisheries and Aquaculture Using Remotely-Sensed Imagery.
    - ChloroGIN project aims to promote in situ measurement of chlorophyll in combination with satellite derived estimates. The ChloroGIN portal is maintained by Plymouth Marine Laboratory. The IOGOOS Secretariat (at INCOIS, Hyderabad, India) is a partner and provides the IOGOOS link to this project. ChloroGIN aims to support the remote sensing needs of communities in large marine regions, which currently include the central-north Indian Ocean and the southwest Indian Ocean areas.
    - Under the IOGOOS framework, there has also been the development of the biogeochemical science alliance called SIBER(Sustained Indian Ocean Biogeochemical and Ecological Research).

More recently, a forum has been established comprising a high level group of leaders in operational oceanography, with the aim of providing a means whereby Indian Ocean Panel (IOP) and SIBER can advocate for operational resources to support their physical and biological observing systems in the Indian Ocean. This new group is called the Indian Ocean Observing System (IndOOS) Resources Forum (IRF).

Another recent initiative has been the development of a joint IOGOOS/SEAGOOS project to build regional capacities in ocean forecasting in the Indian Ocean and South East Asian regions, with the collaborative support of Australia's ocean forecasting community (through BLUElink> Australia).

Indian Ocean Panel of GOOS/CLIVAR (IOP)

The IOP is a pilot project of IOGOOS. The IOP receives underpinning sponsorship through the UNESCO IOC Perth Office and through CLIVAR of the WCRP. CLIVAR is the Climate and Variability project under the World Climate and Research Program

(WCRP) improving the characterisation of the Indian Ocean's relatively poorly understood oceanographic and coupled climatic processes, and how those processes influence island and continental rim countries. The spectrum of oceanic phenomena and related topics within the IOP's science framework includes the improved description, understanding and ability to predict (i.e., model):

- Seasonal monsoon variability;
- Indian Ocean Dipole (ENSO-like phenomenon in the Indian Ocean);
- Madden Julian Oscillation;
- Intra-seasonal (30-90 day period) oscillations and far field impacts (ENSO, hurricane formation, west coast US rainfall);
- Decadal variability;
- Warming trends since the 1970s;
- Ocean circulation (Indonesian Throughflow, shallow and deep overturning circulation);
- Marine ecosystems and biogeochemistry.

IOP is coordinating and using the data from a wide variety of GOOS infrastructure (e.g., deep ocean moorings, ARGO floats, free drifting buoys, satellite-based ocean data, ships of opportunity data, etc). Computer based models that are used to study and predict the oceanography of the Indian Ocean are continually being developed, improved and applied as a result of the observational and analytical outputs of the IOP. The IOP develops the Indian Ocean Observing System (IndOOS) with the deep mooring network component of IndOOS (termed the 'RAMA' array) now approximately 50% implemented (25 out of a 46 planned deep ocean monitoring moorings).

The IOP's work has furthered the characterisation and predictability of oceanographic processes and associated coupled atmospheric/weather process over the Indian Ocean, many of which transmit and have a profound influence on the oceanography and climate (e.g., storms, cyclones, general wind patterns, rainfall, humidity, temperatures) of island and continental rim nations in the IOGOOS/SEAGOOS. It is notable that the Indian Ocean Dipole and Madden Julian Oscillation (MJO) mechanisms manifest in the northern Indian Ocean under strong coupling to the ocean properties that the IOP are uncovering, characterising and modelling. These processes have strong influences on tropical cyclone activity and rainfall. The MJO has also been found to influence the ecology of the tropical Indo-Pacific, such as ocean chlorophyll levels. The IOP's work also has strong contextual relevance to marine industry, in respect to providing underpinning scientific understanding and long term monitoring of ocean processes (relevant, for example, to surface and sub-sea marine engineering design, maritime transport etc) and coupled atmospheric phenomena.

IOP membership in terms of scientists and host institutions in the BOBLME member countries comprises: National Institute of Oceanography, Goa, Indian Institute of Science, Bangalore (India) and Fadli Syamsudin , BPPT, Jakarta, (Indonesia).

Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER)

SIBER is a pilot project of IOGOOS, and will be jointly run under both IOGOOS and Integrated Marine Biogeochemistry and Ecological Research (IMBER) an international program of International Geosphere-Biosphere Programme *(*IGBP) and Scientific Committee on Oceanic Research of the International Council for Science (SCOR).

SIBER was formed as an international science alliance of bio-geochemists and ecologists, generically akin to the IOP but focussing on complementary bio-geochemistry and ecology for the Indian Ocean. In the international SIBER Scientific Steering Committee constituted for implementing the SIBER Project, Scientists from four of the eight BOBLME countries viz. India, Indonesia, Maldives and Thailand, are Members.

SIBER's draft science plan addresses processes in the East Indian Ocean. These include the bio-geochemistry and ecology of dynamically related ocean processes. SIBER's six overarching science themes focus on:

1. Boundary currents: upwelling, filaments, eddies, cross-shelf transport;
2. Equatorial circulation, Indo-Pacific Throughflow, climate change influences;
3. Primary production: controls and fate, marginal seas, grazing, Si & Fe-limitation, N_2 fixation, benthic-pelagic coupling;
4. Bio-geochemical differences: Arabian Sea vs Bay of Bengal;
5. Climate change monitoring in the Indian Ocean through bio-geochemical studies; and
6. Role of higher trophic levels on bio-geochemical and ecological processes.

The IRF will also assist SIBER, in a complementary manner to the way in which it will support the IOP. In this context, there will be important synergy between IOP and SIBER. This refers to SIBER potentially being able to lever resources, such as bio-geochemical ocean observing infrastructure affixed to IOP's physical oceanography moorings and related infrastructure.

Indian Ocean Observing System (IndOOS) Resources Forum (IRF)

The IRF is established under the auspices of IOGOOS. A key objective of the IRF is to facilitate the identification and alignment of institutional resources (e.g., ocean observing infrastructure, scientific capacity and vessel support) for implementation of the programmes of the IOP (and SIBER) in response to the high priority operational needs as they continue to build IndOOS.

Invited members are from India and Indonesia in the BOBLME region, among others (Australia, France, South Africa, Japan and China, as well as the ASCLME).

From the foregoing account, it will be evident that the BOBLME Member countries have a lot to benefit from their association and linkage with IOGOOS and its affiliated regional alliances, particularly in the areas of

- Understanding the oceanographic setting of the Bay of Bengal Large Marine Ecosystem;
- Ocean forecasting and modeling;
- Impact of physical, chemical and biological oceanographic parameters on the BOBLME and its resources;
- Capacity building in oceanography through training, education and awareness;
- Information/data/knowledge sharing/exchange between IOGOOS Member countries and BOBLME member countries.

7. Recommendations

The following recommendations emerged out of the discussion, for consideration and preparation of a Work Plan for implementation during the next two years (2010 – 2012).

General

- BOBLME should become an Associate Member of IOGOOS and actively involve in its programmes and activities relevant to the Bay of Bengal.
- Take up on fast track mode BOBLME project activities in the oceanography discipline (Activities under component 3.1) through forceful participation of BOBLME Member Countries and BOBLME in the Indian Ocean Global Ocean Observation System (IOGOOS) programmes in a meaningful way.
- For this purpose the Oceanographic institutions of the BOBLME countries should become institutional members, if not already done.
- BOBLME should support the implementation of SIBER through facilitating the installation/addition of biogeochemical sensor to the existing and new RAMA moorings in the Bay of Bengal**.**

Capacity Building

- Training should be conducted with the aim to enable the oceanographers in the BOBLME region to effectively participate in the various programmes and projects of IOGOOS and other associated groups viz. IOP/IndOOS/SIBER and IODE.
- BOBLME should support need based Capacity Building in oceanography (physical, chemical, biological and geological), coastal and marine ecosystem management, either on-the-job or through formal training courses, using the training events organized by partners or through special courses, as appropriate.
- Special reference is made to training organized by NOAA, INCOIS, NIO, ChloroGIN Project and the training programmes/facilities of IOC WESTPAC in China.

- Training on hormonisation of standards (sampling methodology, analytical methods, HAB, calibration and data management) for comparability of results is considered particularly essential.

Thematic Issues

- Creating a repository of oceanographic data to foster data exchange.
- Comprehensive oceanographic survey of BoB.
- A new satellite with a pay load to measure surface salinity distribution in Indian Ocean which plays important role in climate system of surrounding regions, be launched (India).
- Programmes for understanding changes in coastal zones at regional scale with respect to global climate change are taken up (SIBER).
- Improved understanding is required for changes in frequency, location and intensity of extreme events and prediction of monsoon onset.
- Agreed sea water quality standards be developed and promoted for areas beyond territorial waters, which are transboundary in nature.
- Combating accidental oil spills in high seas including studies on impact of oil rigs on Bay ecosystem.
- Awareness creation among coastal community on various aspects relating to CZM.
- Information, education and capacity building should be addressed through integrated training programmes and other means.

Draft Work Plan for Improved Understanding of Oceanography and Large-Scale Processes and Dynamics Affecting the BOBLME (August 2010 and December 2011)

Sl. No	Project Activities	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Amount (US$)
1	**General**																		
1.1	BOBLME to be an Associate Member of IOGOOS.																		
1.2	Oceanographic institutions of BOBLME countries to become institutional members of IOGOOS																		
1.3	BOBLME support for implementation of SIBER through facilitating installation/addition of biogeochemical sensors to RAMA moorings in BoB.																		

Sl. No	Project Activities	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Amount (US$)
2	**Thematic Issues**																		
2.1	Comprehensive Oceanographic studies in BOBLME Countries by participating in IOGOOS programmes. (All countries).																		
2.2	Ocean Forecasting and Modelling. (All countries)																		
2.3	Understanding changes in coastal zones at regional scale with respect to global climate change (SIBER). (Bangladesh, Maldives, Indonesia, Thailand, India, Sri Lanka).																		
2.4	Improved understand-ing of changes in frequency, location & intensity of extreme events and prediction of monsoon onset. (All countries)																		
2.5	Development & promotion of agreed sea water quality standards for areas beyond territorial waters (All countries).																		

Sl. No	Project Activities	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Amount (US$)
2.6	Combating accidental oil spills in high seas including studies on impact of oil rigs on Bay ecosystem. (Maldives, India, Sri Lanka, Indonesia, Thailand, and Malaysia).																		
2.7	Keystone ecosystem project on coral reefs, mangroves and sea grass beds. (Maldives, Myanmar, India, Indonesia, Bangladesh, Sri Lanka, Thailand)																		
2.8	Studies on shoreline changes. (Bangladesh, India, Malaysia, Sri Lanka, Thailand)																		
2.9	Establishment and development of *in situ time series stations for ChloroGIN project. (Maldives, Sri Lanka & Thailand)*																		
2.10	Development of an early warning system for detection of HABS using satellite data. (All countries)																		

Sl. No	Project Activities	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Amount (US$)
2.11	Primary productivity modeling - generation of PI parameters. (All countries)																		
2.12	Exploring possibilities of using MERIS high resolution ocean colour data products in understanding coastal dynamics. (All countries)																		
2.13	Developing maps of biological fronts and analysis of feature persistence. (All countries)																		
2.14	Determination of carbon associated elemental fluxes in coastal areas with a view to improve predictive capability of variability of coastal zones due to climate change. (All countries)																		
2.15	Influence of seasonally reversing monsoon winds on variability of water characteristics and circulation in BoB. (All countries)																		

Sl. No	Project Activities	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Amount (US$)
2.16	Monitoring pollution at point and non-point sources. (All countries)																		
2.17	Creating a repository of oceanographic data to foster data exchange (All countries).																		
3.	**Capacity Building**																		
3.1	Training on hormonisation of standards (sampling methodology, analytical methods, HAB, calibration and data management). (All countries)																		
3.2	BOBLME's support for need based Capacity Building in oceanography, coastal and marine ecosystem management.																		
3.3	Training on ocean forecasting & satellite oceanography, CholoroGIN, shoreline changes, modeling, bio-geochemistry, coastal ocean observations and coastal water quality. (All countries)																		

Annexure-1

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Annexure - 2

Regional BOBLME Oceanography Workshop in conjunction with IOGOOS 7 and associated Project Groups.

CityGate Hotel, Perth, Western Australia, 12-16 July 2010

15 July 2010

Agenda

1. Opening of the meeting

2. Adoption of the Agenda

3. Oceanography and large scale dynamic processes affecting the Bay of Bengal Large Marine Ecosystem (BOBLME) - Presentation of Overview by Experts from 8 Member countries

4. Discussion

5. Summing up/closure of the meeting

6. Recommendations

Annexure-3

List of Abbreviations and Acronyms

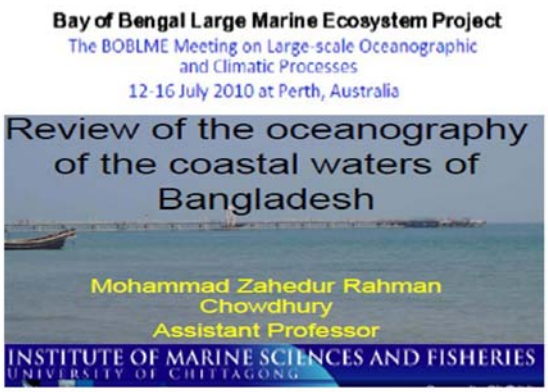
ADCP	Acoustic Dopler Current Profiler
ARGO	Array for Geostrophic Oceanography
ASCLME	Agulhas and Somali Current Large Marine Ecosystems
AWS	Automatic Weather Station
BLUElink	BLUElink> Ocean forecasting Australia
BMKG	Badan Meteorologi Klimatologi Dan Geofisika (The Indonesia Agency for Meteorology Climatology and Geophysics)
BoB	Bay of Bengal
BOBLME	Bay of Bengal Large Marine Ecosystem
BOBMEX	Bay of Bengal Monsoon Experiment
BOBPS	Bay of Bengal Process Studies
BPPT	Badan Pengkajian dan Penerapan Teknologi (Technology Center for Marine Survey Agency for Technology)
BU	Burapha University
C	Centigrade
C/m²/day	Carbon per square metre per day
CESS	Centre for Earth Science Studies
CLIVAR	Climate Variability and Predictability
CMFRI	Central Marine Fisheries Research Institute
CMLRE	Centre for Marine Living Resources and Ecology
COASTMAP-IO	Coastal Mapping Capacity Building in the Indian Ocean
COMAPS	Coastal Ocean Monitoring And Prediction System
CPCB	Central Pollution Control Board
CRV	Coastal Research Vessel
CSIR	Council of Scientific & Industrial Research
CTA	Chief Technical Advisor
CTD	Conductivity Temperature and Depth
CZM	Coastal Zone Management
DBCP	Data Buoy Cooperation Panel
DKP	Ministry of Marine Affairs and Fisheries (Kementerian Kelautan dan Perikanan)
DMH	Department of Meteorology and Hydrology
DO	Dissolved Oxygen
DST	Department of Science and Technology
E	East
EEZ	Exclusive Economic Zone
ENSO	El Niño-Southern Oscillation
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
FAORAP	Food and Agriculture Organisation Regional Office for Asia & the Pacific
Fe	Ferrum (Iron)
FORV	Fisheries & Oceanographic Research Vessel
FSI	Fishery Survey of India
g	gram
GEF	Global Environment Facility
GIS	Geographic Information System
GOOS	Global Ocean Observing System
GRA	GOOS Regional Alliances
GSI	Geological Survey of India
HAB	Harmful Algal Blooms
ICMAM-PD	Integrated Coastal and Marine Area Management – Project Directorate
ICZM	Integrated Coastal Zone Management
IGBP	International Geosphere-Biosphere Programme

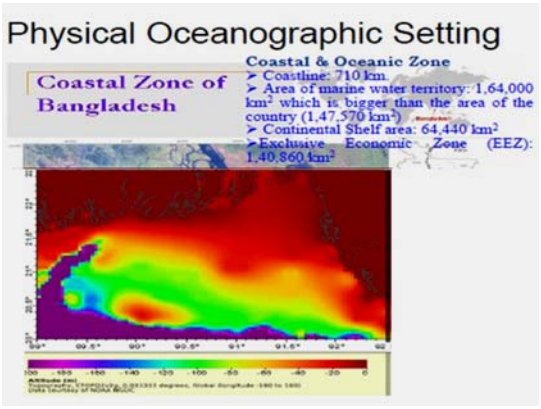
IISC	Indian Institute of Science
IIT	Indian Institute of Technology
IITM	Indian Institute of Tropical Meteorology
IMBER	Integrated Marine Biogeochemistry and Ecological Research
IMD	India Meteorological Department
INCOIS	Indian National Centre for Ocean Information Services
INDOFOS	Indian Ocean Forecast System
INDOMOD	Indian Ocean Modelling and Dynamics
IndOOS	Indian Ocean Observation System
INHO	Indian Naval Hydrographic Office
IOC	Intergovernmental Oceanographic Commission
IOCINDIO	Intergovernmental Oceanographic Commission-Indian Ocean
IOD	Indian Ocean Dipole
IODE	International Oceanographic Data Exchange
IOGOOS	Indian Ocean Global Ocean Observation System
IOP	Indian Ocean Panel
IRF	Indina Ocean Resource Forum
ISBA	International Sea Bed Authority
ISRO	Indian Space Research Oranisation
LIPI	(Lembaga Ilmu Pengetahuan Indonesia) Research Centre for Oceanography Indonesian Institute of Sciences
LME	Large Marine Ecosystem
m	metre
MASS	Morphodynamic and Slope Stability of Andaman Sea Shelf
MEA	Ministry of External Affairs
MERIS	Medium Resolution Imaging Spectrometer
mg	milligram
MJO	Madden Julian Oscillation
MoA	Ministry of Agriculture
MoEn&F	Ministry of Environment & Forests
MoES	Ministry of Earth Sciences
MRC	Marine Research Centre
MRC	Marine Research Centre
N	North
N	Nitrogen
NAL	National Aeronautical Laboratory
NARA	National Aquatic Resources Research and Development Agency
NCAOR	National Centre for Antarctic and Ocean Research
NCMRWF	National Centre for Medium Range Weather Forecasting
NDBP	National Data Buoy Programme
NE	North East
NEERI	National Environmental and Engineering Research Institute
NGRI	National Geophysical Research Institute
NHD	National Hydrographic Department
NIO	National Institute of Oceanography
NIOT	National Institute of Ocean Technology
NOAA	National Oceanographic and Atmospheric Administration
NODC	National Oceanographic Data Centres
NORI	National Oceanographic Research Institute
NPOL	National Physical Oceanography Laboratory
NRB	Naval Research Board
NRSC	National Remote Sensing Centre
OASIS	Ocean-Atmosphere System Research Laboratory
OceanSITES	Global network of open-ocean sustained time-series sites, called ocean reference stations
ONGC	Oil and Natural Gas Commission

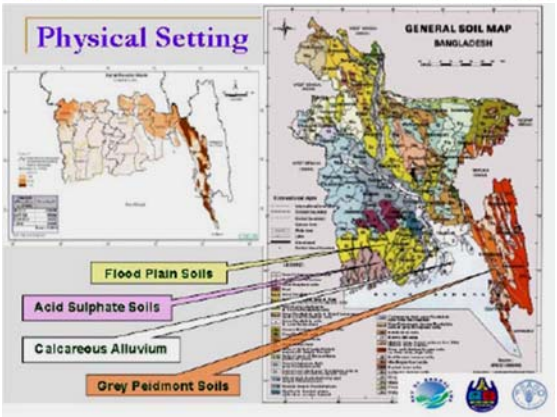
ORCAS	Ocean Reef Coupling in the Andaman Sea
ORV	Oceanographic Research Vessel
PDO	Pacific Decadal Oscillation
psu	Practical salinity unit
R&D	Research and Development
RAMA	Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction
RRL	Regional Research Laboratory
SAC	Space Application Centre
SAFARI	Societal Applications in Fisheries and Aquaculture Using Remotely-Sensed Imagery
SATCORE	Satellite Coastal and Oceanographic Research
SCOR	Scientific Committee on Oceanic Research of the International Council for Science
SEAGOOS	South East Asia Global Ocean Observing System
Si	Silicon
SIBER	Sustained Indian Ocean Biogeochemical and Ecological Research
SK	Sagar Kanya
SOI	Survey of India
SOOP	Ship-of-Opportunity Programme
SST	Sea Surface Temperature
SW	South West
UN	United Nations
UNCLOS	United Nations Convention on Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
US	United States
WCRP	World Climate and Research Program
WESTPAC	Western Pacific
WMO	World Meteorological Organisation
WOCE	World Ocean Circulation Experiment
XBT	Expendable Bathy Thermograph

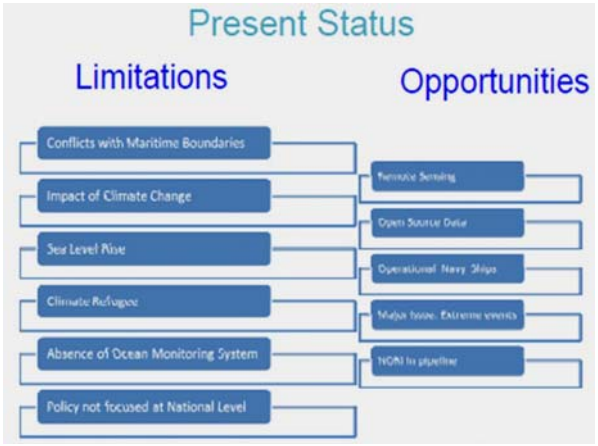
Annexure-4

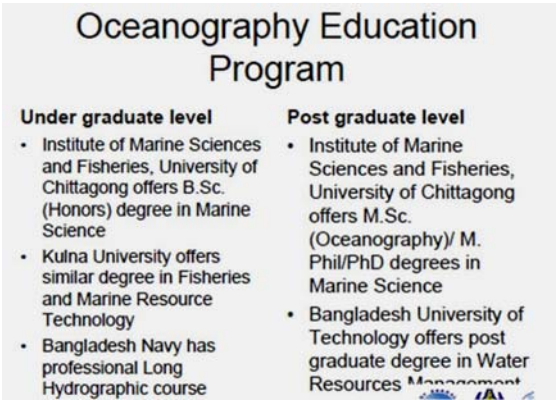
Presentation of Bangladesh Country Report

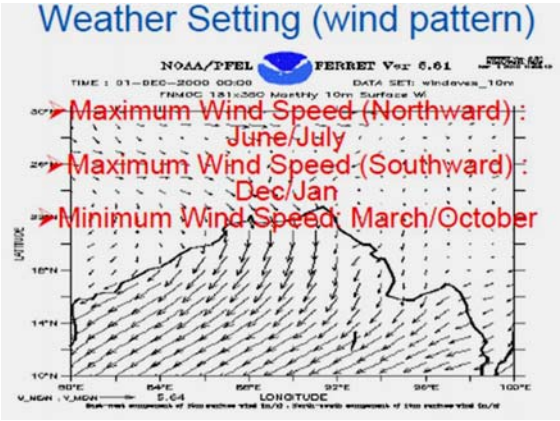






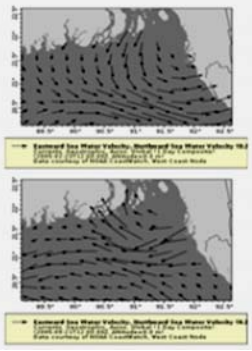




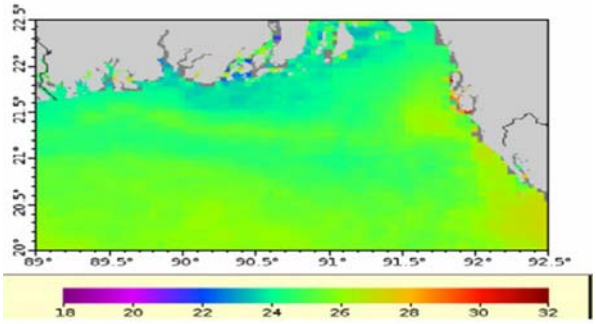


Reversing Current Pattern

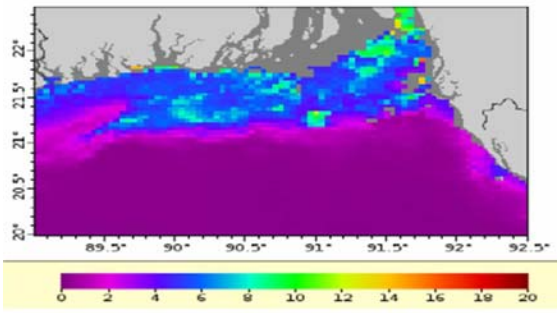
- During the spring time clockwise circulations of water is occurred and anticlockwise circulation is focused during the autumn.
- These circulation system influence the seasonal pattern of Bangladesh and shows the wind directions in this country.



Sea Surface Temperature(SST)



Productivity (Chlorophyll *a*)



Cyclones

- Intensity of Cyclones is increasing
- Cyclone return period becomes shorter
- Meteorological disturbances increases
- Coastal low laying area exposed to repeated calamities
- Storm surge during spring tide and raining season causes severe destructions

Policy

- **Coastal Zone Policy**
  - Adopted in 2005,
  - mainstreaming coastal zone management and strategic planning and programme development,
  - emphasis for land zoning in conjunction with the landuse policy,
  - does not address sea-level rise of the coast,
- **National Landuse Policy**
  - Adopted in 2002,
  - Prime objective is to restrict the conversion of agricultural land,
  - address the issues related to land management to maximize the return from its use,
  - does not address the physical destruction of land due to natural causes such as river bank erosion etc.

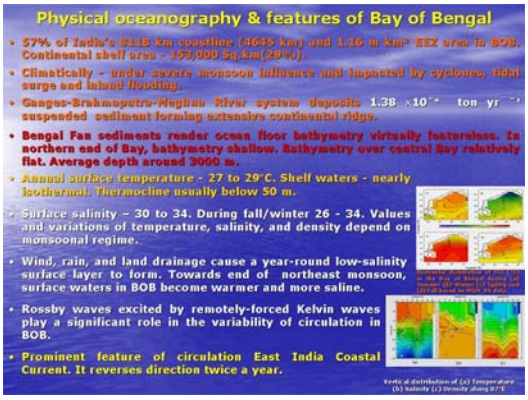
~ Functioning Work plan not in place
~ Policies are not reflected in reality

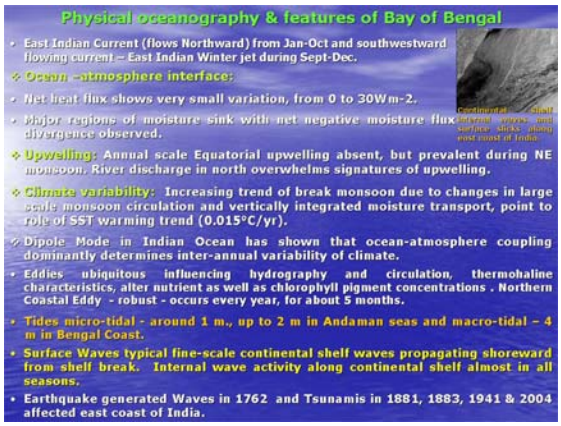
Conclusions

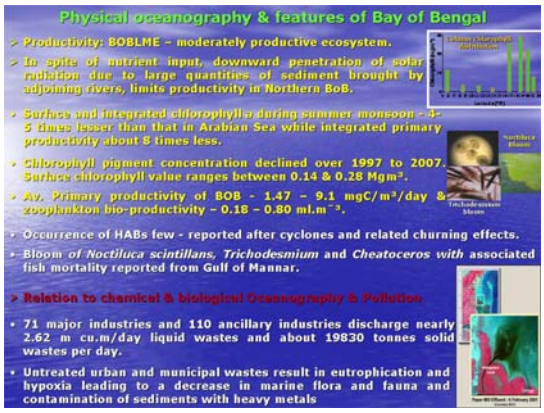
- A few policies concerning exclusively the marine environment has been framed.
- Environmental policy 1991 and 1992 focused attention on the marine environment.
- Regular oceanographic survey should be conducted.
- Ocean observation system should be implemented immediately, should become the member of IOGOOS, IndOOS, ARGO network.
- Research on oceanography should be prioritized at national level.
- Observation, understanding, proper prediction of oceanic phenomena could attribute to sustainable resource management and minimize colossal damage due to Climate

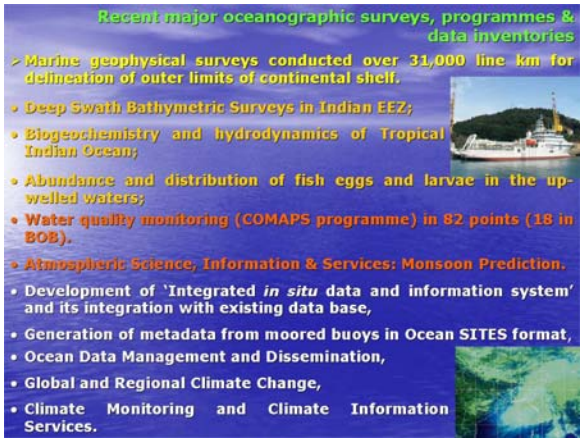
Annexure-5

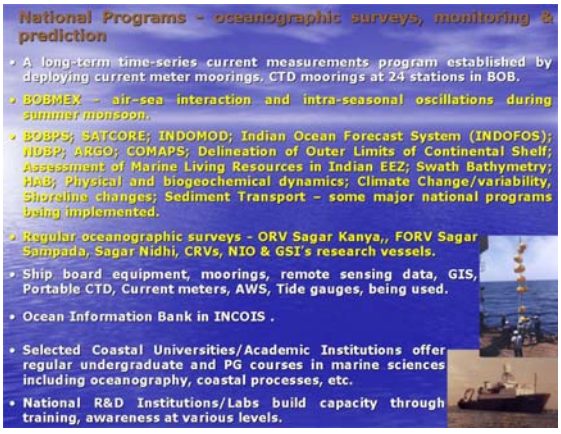
Presentation of India Country Report





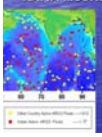






International, Regional, Global Programs, Regional Coordination & Partnerships

- IOGOOS Secretariat – INCOIS, Hyderabad.
- Major initiatives - Indian Ocean Observations for Climate, Data & Information management, capacity building, keystone ecosystems project, shoreline change monitoring project, prawn project, etc.
- Indoos addresses observations on role of Indian Ocean in climate system and its predictability. RAMA,ARGO, SOOP/XBT lines, Drifting Buoys, etc., used in generating data and data products. India a Member in IOP and data portel for Indian Ocean data maintained by INCOIS.
- DBCP - joint body of WMO and IOC for coordinating use of data buoys to observe atmospheric and oceanographic conditions. NIOT Scientist - Vice-Chair for Asia & represented by Scientists from NIOT, NIO, INCOIS, NAL, etc.
- Argo Project, implemented by INCOIS. Out of 175 floats deployed by India, 79 active. INCOIS Regional Data Centre for Indian Ocean.
- India provides 60 day/yr ship time for implementing RAMA. In Bay of Bengal, 3 RAMA moorings deployed and maintained from 2007



- Remote sensing data provide inputs for coastal land use, shoreline changes, SST, Currents, biological productivity (Ocean Colour), shallow water bathymetry and benthic cover.
- *INHO Multi-beam training course - Goa, March 2008. Leadership development workshop - Hyderabad, May 2008. Argo User's workshop Hyderabad July 2008. Tsunami modelling and innundation mapping training course - Hyderabad, Oct - Nov 2008. Second Multi-beam training course - Goa, April 2009*

Institutional arrangements & mechanisms for oceanographic survey, data gathering, storage and analysis

- MoES: Matters relating to Ocean, meteorology, seismology, marine environment; HRD; international collaboration and cooperation; laws and regulatory measures.
- Ministry of Agriculture; R&D in fisheries, fisheries education, international cooperation, Fishing and fisheries.
- MoEn&F: Environment and Ecology of coastal waters excluding high sea environment.
- Ministry of External Affairs: Matters relating to Law of the Sea & ISBA.
- NIO under CSIR : Oceanographic Research and Survey.

National Institutes such as NCAOR, NIOT, CMLRE, ICMAM-PD, IMD, NCMRWF, IITM (all under MoES), GSI, NHD, ONGC, Fishery Research Institutes such as FSI, CMFRI, etc., carry out oceanographic surveys, supported by National Research laboratories (NIO, RRL, NGRI, NPOL, NEERI, Naval Research Board), ISRO, NRSC, SAC, CPCB, DST, SOI, CESS, selected Academic Institutions, Universities, IISC, a few IITs with faculty and facility for oceanographic research.

INCOIS Ocean Information Bank - serves as National Oceanographic Data Centre of India and a National repository of marine data.

Autonomous institutions & field labs under MOES; NIO under CSIR act as regional R&D and training centres.

A world class training programme in Earth System Sciences and Climate being put in place.

Gaps

- No proper mechanism for monitoring pollution at point and non-point sources and lack of scientific information for managing and reducing pollution.
- Lack of long-term time-series multi-disciplinary observations both in coastal and deep-sea regions to understand various processes with fine resolution.
- Oceanographic data lying scattered in different Agencies/Organisations.
- Studies to understand influence of seasonally reversing monsoon winds on variability of water characteristics and circulation in BOB part of Indian Ocean; very limited.
- No detailed studies on dioxin distribution and role of organic liganes (humic compound and its yellow substances) in oceanography, productivity & pollution
- Atmospheric episodes leading to considerable damage in coastal regions, yet to be forecasted with sufficient accuracy.
- Reliable data on nutrient , bio-geochemistry, chlorophyll and other biological characteristics from the Bay of Bengal - elusive.
- Participatory approach in ICZM and ecosystem management yet to receive adequate attention.
- Most Acts, Rules & Regulations yet to be enforced for want of adequate field level mechanism.
- Capacity building needs (staff training) : Virtual lack of trained manpower in physical, chemical and geological oceanography
- Access to satellite and related products / means –A non-issue.

Recommendations for priority actions and measures required

National

- Unifying efforts and creating a repository of oceanographic data.
- Essential parameters (waves, tides, currents and sediment characteristics) be monitored using satellite imageries & impact models generated for prediction of shoreline changes.
- More emphasis for comprehensive oceanographic survey of BOB.

Regional/Sub-regional

- Abatement and elimination of adverse impacts of land-based sources of pollution.
- Incorporation of observations for bio-geochemical parameters to enhance interdisciplinary research in Indian Ocean sector.
- A new satellite with a pay load to measure surface salinity distribution in Indian Ocean which plays important role in climate system of surrounding regions, be launched.
- Programmes for understanding changes in coastal zones at regional scale with respect to global climate change is taken up.

BOBLME Level

- Agreed sea water quality standards be developed for areas beyond territorial waters, which are transboundary in nature.
- Awareness creation among coastal community on various aspects relating to CZM.
- Combating accidental oil spills in high seas including studies on impact of oil rigs on Bay ecosystem.
- Information, education and capacity building should be addressed through integrated training programmes. Institutionalisation of training in oceanography by creating a world class facility.
- Studies on distribution of dioxin and role of organic liganes in BOB oceanography, biodiversity and pollution.

Summary of trans-boundary oceanographic issues and concerns

- Land based sources of pollution- a major threat to entire coastal and marine ecosystem.
- Measures taken to prevent erosion/ accretion are not fruitful due to lack of proper monitoring and understanding of the coastal processes.

- Integrating satellite derived data in sediment transport and shoreline change prediction models and ecosystem modelling.
- Sheer quantities and content of suspended materials and nutrients entering BOB, affect coastal ecosystem health and pose public health risk.
- Strengthening institutional infrastructure for information exchange.
- Use of satellite communication system on a regional basis for oceanographic studies.
- Preparation of compendium of regional oceanographic information on important aspects such as permissible levels of pollutants, policies, legal framework, regulations, etc.
- Strengthening and improving scientific publications and journals in Oceanography.
- Training of oceanographers in specific disciplines and specializations.
- Determination of carbon associated elemental fluxes in coastal areas which are potential contributors to land-ocean interaction, with a view to improve predictive capability of variability of coastal zones due to climate change.

Conclusions

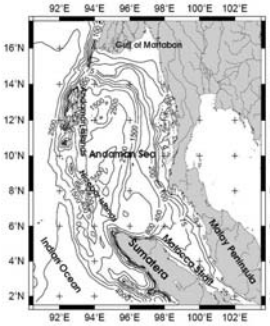
- Past-decades have seen major emphasis on West Coast of India (Arabian Sea) than Bay of Bengal.
- An analysis of present status of oceanographic studies and dynamic processes affecting BOB reveal the absence of a comprehensive and coordinated long-term interdisciplinary approach to the entire issue.
- Emphasis therefore to be on long-term comprehensive oceanographic studies covering all major physical, chemical, biological and geological aspects and climate variability/change at National/Sub-regional/regional levels.
- Top priority to be given for human resource development through capacity building in oceanography in the region. A regional level state-of-the-art training facility – need of the hour.
- More active participation of BOBLME countries in the international, regional and global programmes on oceanography.
- Creation of a oceanographic data bank at National/Sub-regional/Regional and BOBLME level for exchange of information.

Annexure-6

Presentation of Indonesia Country Report

MODELLING OF GENERAL CIRCULATION
IN THE ANDAMAN SEA AND MALACCA STRAIT

By:
Syamsul Rizal



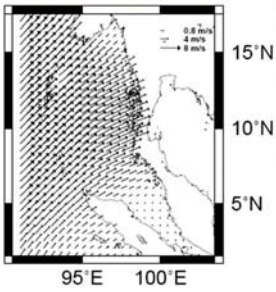
The Andaman Sea is located along the north-eastern side of the Indian Ocean between the Malay Peninsula at the east and the Andaman - Nicobar islands chain at the west.

The Andaman and Nicobar islands are volcanic in origin.

As a result the water depth in this region changes rapidly from over 3000-4000 meters in the Indian Ocean to approximately 200 meters in the area around the islands, returning to deeper than 2500 meters in the centre of the Andaman Sea.

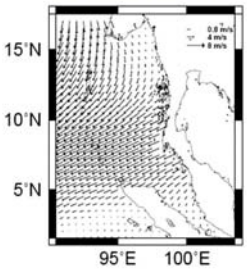
SW and NE Monsoon

SW MONSOON
(from June through September)



During the SW monsoon, the winds move from the south-west to the north-east. Strong winds between June and September lead to maximum rainfall over most parts of the Indian subcontinent

NE MONSOON
(from December through February)



During the NE monsoon, the winds move from the north to the south-west

HAMSOM MODEL

Three-dimensional baroclinic primitive equation model

x-component momentum equation :

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}-fv=-\frac{1}{\rho}\frac{\partial p}{\partial x}+A_h\nabla^2 u+\frac{\partial}{\partial z}\left(A_v\frac{\partial u}{\partial z}\right)+F_x$$

y-component momentum equation :

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}+fu=-\frac{1}{\rho}\frac{\partial p}{\partial y}+A_h\nabla^2 u+\frac{\partial}{\partial z}\left(A_v\frac{\partial v}{\partial z}\right)+F_y$$

Continuity equation:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0.$$

Hydrostatic equation:

$$\frac{\partial p}{\partial z}=-\rho g,$$

State equation of seawater:

$$\rho=\rho(S,T,p)=\rho_o+\rho'$$

Heat transport equation:

$$\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}+w\frac{\partial T}{\partial z}=K_h^T\nabla^2 T+\frac{\partial}{\partial z}\left(K_v^T\frac{\partial T}{\partial z}\right)+S_T,$$

Salt transport equation :

$$\frac{\partial S}{\partial t}+u\frac{\partial S}{\partial x}+v\frac{\partial S}{\partial y}+w\frac{\partial S}{\partial z}=K_h^S\nabla^2 S+\frac{\partial}{\partial z}\left(K_v^S\frac{\partial S}{\partial z}\right)+S_S,$$

Boundary Conditions

At the surface ($z=\zeta$) and the bottom ($z=-H$)

At the open boundaries, the sea surface elevations are obtained from the data which are calculated from the tidal components.

Kinematic boundary conditions:

$$w_\zeta=\frac{\partial\zeta}{\partial t}+u_\zeta\frac{\partial\zeta}{\partial x}+v_\zeta\frac{\partial\zeta}{\partial y}$$

$$w_{-H}=u_{-H}\frac{\partial H}{\partial x}+v_{-H}\frac{\partial H}{\partial y}$$

Dynamic boundary conditions:

at the surface :

$$A_v\frac{\partial u_\zeta}{\partial z}\quad A_h\left(\frac{\partial u_\zeta}{\partial x}\frac{\partial\zeta}{\partial x}+\frac{\partial u_\zeta}{\partial y}\frac{\partial\zeta}{\partial y}\right)=\tau_x^{(s)}$$

$$A_v\frac{\partial v_\zeta}{\partial z}\quad A_h\left(\frac{\partial v_\zeta}{\partial x}\frac{\partial\zeta}{\partial x}+\frac{\partial v_\zeta}{\partial y}\frac{\partial\zeta}{\partial y}\right)=\tau_y^{(s)}$$

at the bottom :

$$A_v\frac{\partial u_{-H}}{\partial z}\quad A_h\left(\frac{\partial u_{-H}}{\partial x}\frac{\partial H}{\partial x}+\frac{\partial u_{-H}}{\partial y}\frac{\partial H}{\partial y}\right)=\tau_x^{(b)}$$

$$A_v\frac{\partial v_{-H}}{\partial z}\quad A_h\left(\frac{\partial v_{-H}}{\partial x}\frac{\partial H}{\partial x}+\frac{\partial v_{-H}}{\partial y}\frac{\partial H}{\partial y}\right)=\tau_y^{(b)}$$

Model Arrangements

The model region: 90.5 E to 103.5E and 1.5 N to 17.5 N

Space increment : $\Delta x = \Delta y = 10$ Minutes

Time increment : $\Delta t = 5$ Minutes = 300 seconds

Vertical Layers: 19 Layers

1. 0 - 10 m
2. 10 - 20 m
3. 20 - 30 m
4. 30 - 50 m
5. 50 - 75 m
6. 75 - 100 m
7. 100 - 125 m
8. 125 – 150 m
9. 150 – 200 m
10. 200 – 250 m
11. 250 – 300 m
12. 300 – 400 m
13. 400 – 600 m
14. 600 – 800 m
15. 800 – 1000 m
16. 1000 – 1500 m
17. 1500 – 2000 m
18. 2000 – 4000 m
19. > 4000 m

THE DATA

Bathymetry:

From the Digital Relief of Surface of the Earth (ETOPO 5), Boulder Colorado : National Geophysics Data Center

Tides:

At the open boundaries, Amplitudes and Phases of the five major tidal constituents (M2, S2, N2, K1, O1) are prescribed from the Global Tide Model (*Zahel et al.*, 2000).

T and S:

From climatological data of *Levitus* (1982)

THE DATA

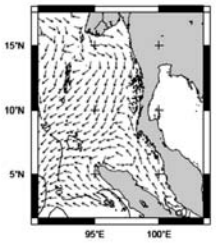
Atmospheric Forcing:

From the NCEP/NCAR reanalysis data

Variable	Level	Unit	Total Grid
Sea Level Pressure	Surface	Pascal	147 x 73
Air Temperature	2 m	°K	192 x 94
Specific Humidity	2 m	kg/kg	192 x 94
U-Wind	10 m	m/s	192 x 94
V-Wind	10 m	m/s	192 x 94
Precipitation Rate	Surface	kgm^2/s	192 x 94
Total Cloud Cover	Surface	%	192 x 94

Results and Discussion

Long term surface currents due to tides, wind and heat flux (1985-2003) December through February (NE monsoon) average



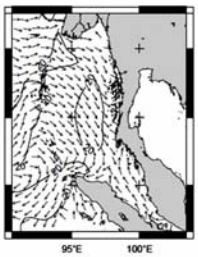
During NE Monsoon, the surface water masses entry the Andaman Sea along a narrow band close southerly of Cape Negrais.

These water masses move to the south and leave the Andaman Sea in the wide area between south of the Andaman Islands and Sumatera. Parallel to Andaman Island in the Indian Ocean a southward current is shown.

A second surface water masses enter the Andaman Sea from the north-east side of the Malacca Strait. It spreads to the borderline between Thailand and Myanmar.

An anticlockwise gyre is located north of Sumatera between the island Weh and Lhokseumawe. This gyre blocks the outflow of the Malacca Strait over a part of its whole breadth

Long term surface currents due to tides, wind and heat flux (1985-2003) June through September (SW monsoon) average.



During SW Monsoon, the surface water masses enter the Andaman Sea over a long section from Cape Negrais to the north of Nicobar islands.

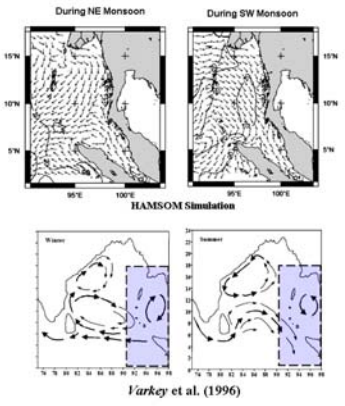
The outflow of the Andaman Sea surface water is concentrated between the south of Nicobar islands and Sumatera.

The local anticlockwise gyre north of Sumatera vanishes. A recirculation regime generated, with water masses coming from the Andaman Sea re-circulating along the north coast of Sumatera to Indian Ocean.

The second entry of surface water masses into the Andaman Sea still occurs. However, it is closer to the coast of Malay Peninsula and flows towards the island Phuket.

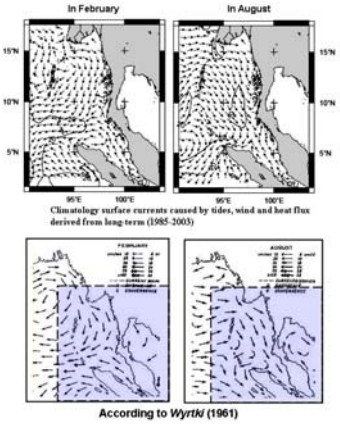
In the Malacca Strait:

The surface flows always north-westward to the Andaman Sea for both, SW and NE monsoon, since the sea surface elevation in the south-east domain is always higher than that in the Andaman Sea both for the SW and NE monsoon (Wyrtki, 1961).



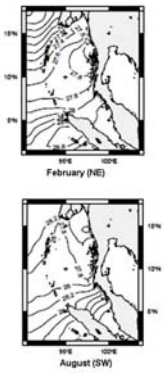
In general, the patterns of circulation are not similar to that of *Varkey et al.* (1996).

They found that there is one main gyre for each season in the centre of the Andaman Sea, i.e. a clockwise gyre during the NE monsoon and an anticlockwise gyre during the SW monsoon.



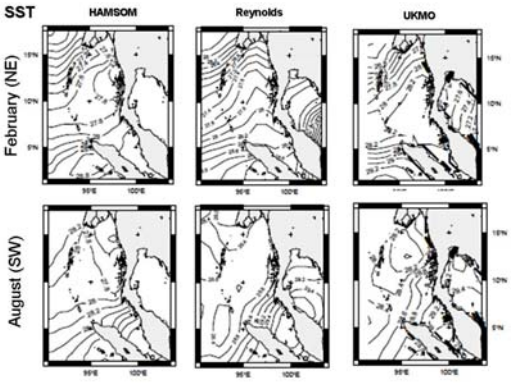
The climatological surface circulations for the months February and August obtained by averaging over the period 1985-2003.

There are similar to our results of seasonal circulation patterns and also to the work of Wyrtki's (1961).

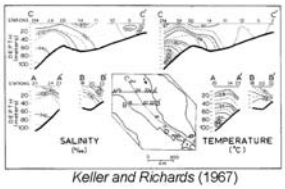


SEA SURFACE TEMPERATURE (SST)
during NE and SW monsoon based on HAMSOM

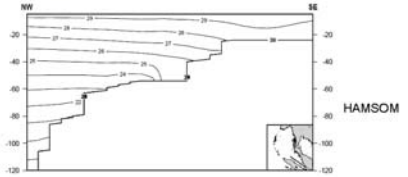
Maximum temperatures for both cases occur in the Malacca Strait and the Indian Ocean near Sumatera Island.



Temperature
Vertical Cross Section in **April 1961**

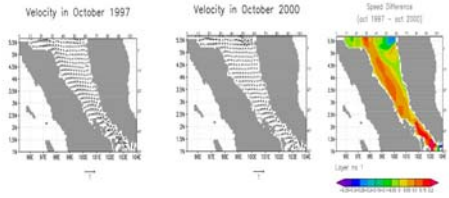


Keller and Richards (1967)

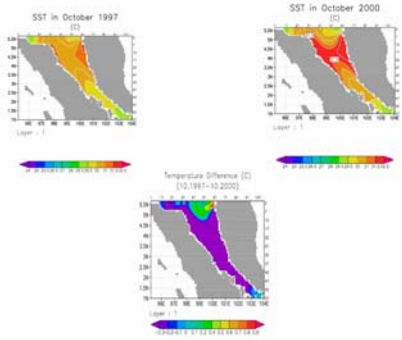


Difference

IOD Positive (1997) and Normal Year (2000).



- **Temperature**



Conclusions

- **Surface current distributions in the Andaman Sea and the northern part of the Malacca Strait change seasonally, depending on the two different monsoon situations.**
- **The good agreement of the general circulation pattern from Wyrtki (1961) with the simulation results confirms Wyrtki's work.**

Conclusions

- **The temperature vertical cross sections are in good agreement with those observed by Keller and Richards (1967).**
- **There are vertical gradients of temperature in the Malacca Strait with surface values 29° C for temperature and bottom values of 19° C.**

Recommendation

- The model results should be validated with the up to date the measurements and remote sensing data

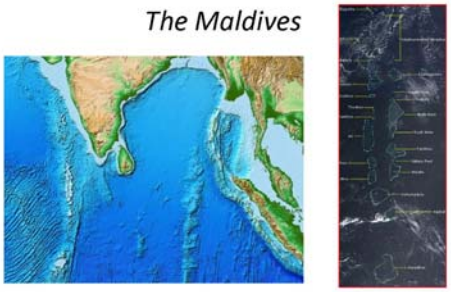
Annexure-7

Presentation of Maldives Country Report

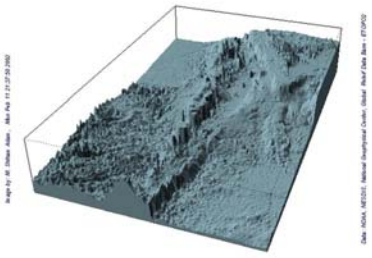
Oceanography and Large Scale Processes affecting the BOBLME

M. Shiham Adam
Marine Research Centre
Republic of Maldives

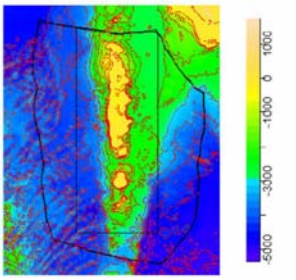
The Maldives



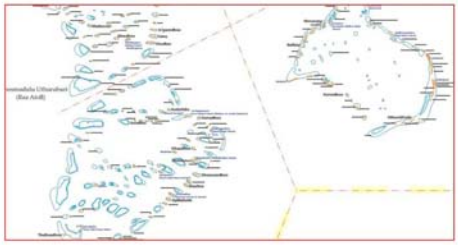
Bathymetry around Maldives



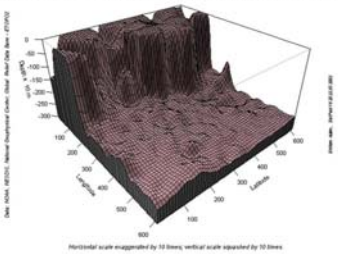
Bathymetric Contour Plot ETOP2 data



Close up to islands and atolls



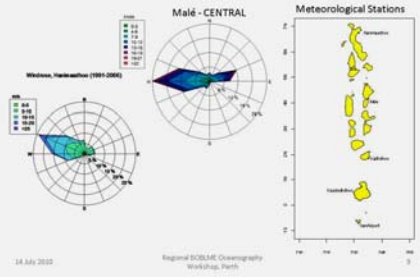
Close up of a Channel, ETOPO2 data



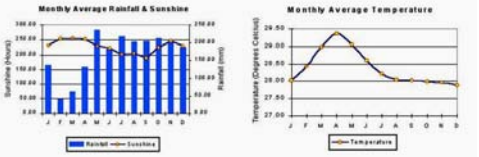
Latitudinal Variations

- Strength of the monsoonal reversal increased to the north
- Incidence of severe tropical storms increase to the north
- Significant wave height increase to the north
- Primary productivity increase in the north
- Net solar radiation increase slightly to the north
- Surface salinity is greatly affected by incursions of water from the Bay of Bengal, but tends to increase in the north
- Levels of DO at 100m to 200m increase to the south
- Eddy energy (a measure of probability of mesoscale eddy occurrence) increase to the south

Wind Patterns



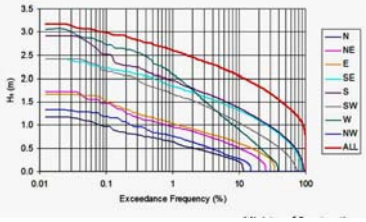
Rainfall, Sunshine and Temperature



Tide Levels Reported for Malé Region

Tidal level referred to MSL	
Highest Astronomical Tide (HAT)	+0.64 m
Mean higher High tide water (MHHW)	+0.34 m
Mean Lower High Water (MLHW)	+0.14 m
Mean Sea-level	0 m
Mean Higher Low Water (MHLW)	-0.16m
Mean Lower Low Water (MLLW)	-0.36m
Lowest Astronomical Tide (LAT)	-0.56m
Tidal range	1.2m

Predicted Wave Heights

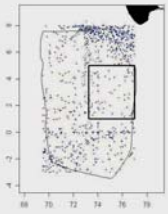


Main surface currents features

South West Monsoon, May to October (except EJ during Inter-monsoon periods)

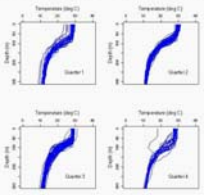
North East Monsoon December - March

NODC Observations of XBT/MBT Casts

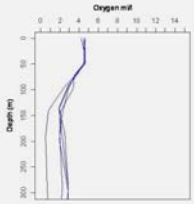


http://www.nodc.noaa.gov

XBT/MBT sub-surface temperature

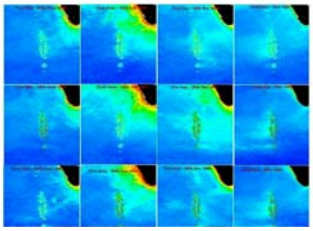


Oxygen Concentration by Depth



Observations in the East Central Box

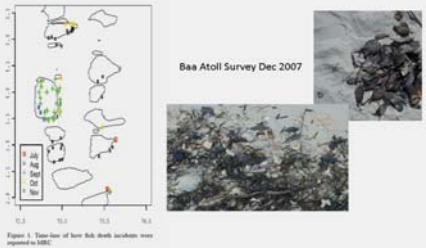
Primary Productivity ..



HABs (?) – Ungoofaaru, 2007

Ungoofaaru , Raa Atoll, December 2007
Very localized,

Unusual Deaths of Red-tooth trigger fish August 2007 – January 2008



Mass Death of Mushimas (Scads)


Fish death in B. Kamadhoo on 24th and 25th November 2007

A part from the reported fish deaths of the above mentioned species, an isolated unprecedented incident of fish death of mainly blue striped herrings (*Herklotsichthys quadrimaculatus*, *guadrialus*) and big eye scads (*Selar crumenophthalmus*, *maalianus*) occurred during this same period on B. Kamadhoo. This large-scale event of the death of big eye scads and herrings occurred as the island harbour starting from the 24th of November 2007 (refer photos 12 - 14 below).

The harbour has a single entrance on its northern side and the absence of a second opening decreases the amount of circulation in the area. The water in the harbour was murky and greenish grey in colour.

Oceanographic Surveys - Maldives

- Research Cruise of RV Sonne; Dec 1997 – Jan 1998
  - Institut für Meereskunde of the University of Hamburg as part of the International World Ocean Circulation Experiment (WOCE)
  - Data available

Oceanographic Surveys ..

- TARA Expedition
  - 3 year expedition starting from September 2009.
  - Multi-disciplinary team of scientists from several countries.
  - Visited Maldives in April 2010
- Objectives
  - Mapping the distribution of the phyto/zoo plankton species.
  - Survey and study of coral reef ecosystems
  - Using state of real-time imaging techniques for cell sorting and photographing
  - Data collection of physical aspects of the oceans
- Expedition on going.. Data not available yet.

Implementation of International, Regional or Global Programmes

- Not been active in the regional programmes relating to IOC
  - Limited or no capacity; not been able to benefit form the large number of capacity building activities going on in the region
- Member of IOCINDIO
- Member of the IOGOOS; Department of Meteorology focal point
- COASTMAP – Initiative formed following the tsunami

Gaps in Knowledge that are of immediate relevance

- Lack of understanding on coastal hydrodynamics
  - Seasonal and regional variation in primary productivity
  - Possible link between primary productivity and distribution and abundance of livebait resources
  - Effect of atoll geomorphology on the productivity and retention within the atoll basin
- Waves and current around the coastal areas
  - Reef health and resilience
  - Reef connectivity

Institutional Arrangements

Marine Research Centre	Environmental Protection Agency & Dept. of Meteorology	Maldives College of Higher Education
Under Ministry of Fisheries & Agriculture Mandate to undertake research fisheries and Marine resources + coral reefs	Ministry of Housing & Environment Implementation of Environmental Regulations + Research on Environment Operational Meteorology Coordinates the collection of tide gauge data	MoE / Dept. of Higher Education About to transform to 'Maldives University' No science Department yet, mainly (educational) teaching collage

Recommendations

- National
  - Revisit the mandates of the related institutions (EPA, MRC, Dept of Meteorology) to redefine the activities relating to the physical and biological oceanography
  - Implement a strategic human resources capacity building in physical and biological oceanography.
  - Increase Maldives' participation in the regional (IOC related) activities
- Regional / Sub Regional / BOBLME Level
  - Engage in IOGOOS activities relevant to BOB region
    - SIBER / IRF activities.

Annexure-8

Presentation of Myanmar Country Report

Ocean-Atmosphere Interaction Effect On Monsoon during 2002

U CHIT KYAW-ASSISTANT DIRECTOR, DMH MYANMAR
Research group member -Y.K Somayajulu, NIO. India
D. Shankar NIO. India
A.M Almeida, NIO. India
Major Ye Lwin, NAVY (Myanmar)

Abstract

During 2002 15April-28May, Myanmar-India Joint Oceanographic Research in the Bay of Bengal. The data of this observation show that the Ocean-Atmosphere interaction some effect on onset phase of South West Monsoon, activities of Cyclonic storms and rainy condition. SST (Sea Surface Temperature), Q (Heat Budget), (d) Conductivity, S (salinity) and Sea water current of sub-surface layer (about 200 M depths) are mainly governed on monsoon criterion. In this paper discuss about the relation of these parameters and behavior of pre-monsoon weather conditions.

Introduction

The physical oceanography observation made during cruise (Sakar Kanya research vessel-SK-175) include vertical profile of temperature and salinity, measured using a SeaBird SBE 9/11plus, CTD(Conductivity-Temperature-Depth) and a Seacat SBE 19 profiler (portable CTD), and vertical profiles of current measured using the ship-borne ADCP (Acoustic Doppler Current Profiler). The meteorological observations made during the cruise include data from onboard AWS (Automatic Weather Station) and measurements of Sea Surface Temperature (SST), atmosphere pressure, wind speed and direction and dry and wet bulb temperatures made every three hourly using a Bucket Thermometer and Standard Met-kit.

Methodology and Data collection

1. The cruise can be divided into two distinct phases on the basis of prevailing weather. Till 10 May, the weather was calm and the winds were gentle (Figure P.1). Satellite measurements provide a synoptic view of the atmospheric circulation and show that winds picked up in the southern Andaman Sea (outside the region of survey) by 7 Day May , and strong winds were measured on board after 10 May. A depression existed in the survey region by 12 May (Figure P.2), and satellite data that it rained over parts of the survey region from 10 to 15 May (Figure P.3), when the CTD observations ended. The formation of the depression can be taken took herald the onset of the summer monsoon over the Andaman Sea.

. **A consequence was that the surface of the sea, which was warming till then, cooled rapidly after 10 May, the average SST in the middle of the basin dropping by 2□C in just 2 days (Figure P.1).**

Discussion

2. The data collected during this cruise are important because very little is known of the hydrography and circulation in the Andaman Sea, and the eastern Andaman Sea in particular is poorly surveyed. Data from satellites, as seen above, provide vital information on a synoptic scale, but satellites are incapable of providing information on sub-surface conditions. This can be only by moored instruments and cruises.

1.The alongshore wind at 94□E (zonal wind) was weakly upwelling favourable till 10 May, but it strengthened thereafter (Figure P.1). At 12□N and 13□N, the along shore wind (meridional wind) was upwelling favourable till 10 May, but swung around thereafter to favour downwelling (Figure P.1). These changes in the local winds are reflected in the CTD observations. While interpreting these data, it must be noted that the Andaman Sea is a small basin and responds rapidly to a change in winds. Hence, a section has to be covered quickly (in, say, a day or two) in order to ensure a consistent interpretation of the variability across it. The two zonal vertical sections at 12□N and 13□N shown in Figure P.4 meet this requirements, but the meridional vertical section at 94□E does not, 5 of the 7 stations on this section being covered during 22-25 April and the last 2 on 7 May.

2. Downwelling, and therefore a poleward geostrophic coastal current, is evident in the temperature, salinity, and density fields at both 12□□ and 13□□ (Figure P.4). This is also seen in the meridional current measured by the ADCP (Figure P.5); consistent with the downwelling observed at 12□N (Figure P.4), the cross-shore (zonal) flow measured by the ADCP is towards the coast (Figure P.5). A likely reason for the stronger downwelling observed at 12□□ in comparison to that at 13□□ is that the downwelling favourable winds had acted on the sea for 2 days more when the southern section was surveyed. The net current, however, is a combination of both geostrophic and Ekman flow, and the latter was almost due eastward across the basin after the winds settled to southwesterly by 15 May (Figure P.2); this was evident from the eastward movement of surface drifters that were deployed in the central Andaman Sea after 15 May as part of the Ocean Observing System programme of NIO .

Results

1.SST in the Andaman Sea (Figure P.1), the temperature of the isothermal surface layer also decreased from about 32 □C at 94□E, 14□N on 7 May to less than 30□C at 96.5□E, 12□N on 14 May, and the depth of the isothermal layer increased owing to wind-forced mixing from less than 20m to about 40m (Figure P.4). The nature of the survey makes it difficult to separate the spatial variability from the temporal variability, but the consistent change seen in the winds and SST across the basin in satellite-derived estimates (Figure P.1) suggests that this observed deepening of the surface layer is a basin-wide phenomenon. Consistent with the satellite-derived rainfall data (Figure P.3), the surface is also lower towards the later part of the cruise, but here too it is not possible to separate the spatial variability from the temporal.

2.In sprite of this drawback, the data collected during this cruise are important because very little is known of the hydrography and circulation in the Andaman Sea, and the eastern Andaman Sea in particular is poorly surveyed. Data from satellites, as seen above, provide vital information on a synoptic scale, but satellites are incapable of providing information on sub-surface conditions. This can be only by moored instruments and cruises

3.The seasonally reversing hydrography and circulation that is typical to the monsoon-forced north Indian Ocean, including the Andaman Sea, implies that similar surveys covering the other seasons in the annual cycle are required to map and understand the variability. Given the large number of atmospheric disturbances that from in this basin and its rich fisheries, it is important to understand the physical oceanography of this basin. The data collected during this cruise can help plan better future physical oceanography programmes in the region.

4.Including the Andaman Sea, implies that similar surveys covering the seasons in the annual cycle are required to map and understand the variability. Given the large number of atmospheric disturbances that form in this basin and its rich fisheries, it is important to understand the physical oceanography of this basin. The data collected during this cruise van help plan better future physical oceanography programmed in the region

5.The cruise period can be divided into two distinct phases on the basis of prevailing weather. Till 10 May, the weather was calm and the winds were gentle and strong winds were measured after 10 May.
The average SST in the middle of the basin dropped by 2°C in just 2 days after 10 May

Conclusions

1. **SST is directed govern to the ocean-atmosphere interaction processes.**
2. **Heat budget of sub-surface layer of ocean (Bay of Bengal) is primary source of these interaction.**
3. **Heat transports from Solar Radiation is major cause.**
4. **Vertical ocean currents due to Upwelling and Down welling by the heat budget of ocean and wind-pressure system over the sea surface.**
5. **Upwelling is one of causes of perturbation of cyclone activities and onset phase of monsoon during pre -monsoon period.**
6. **Strong interaction between ocean and atmosphere is more favorable to activities of onset phase(faster than normal) of South West Monsoon. *(reversely due to delay)***

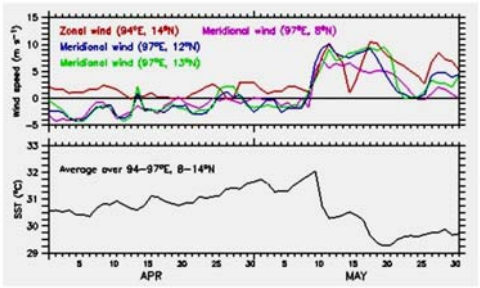
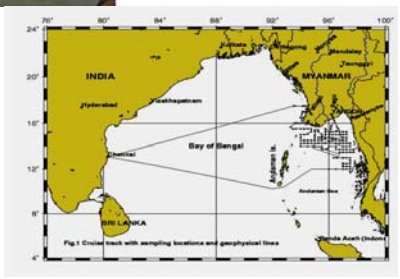
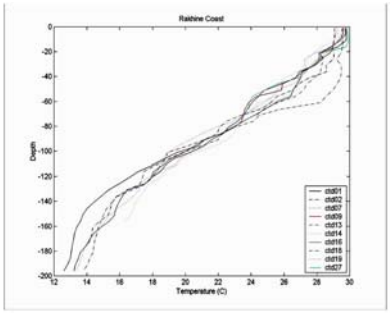
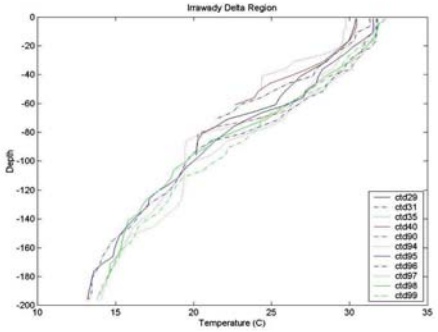
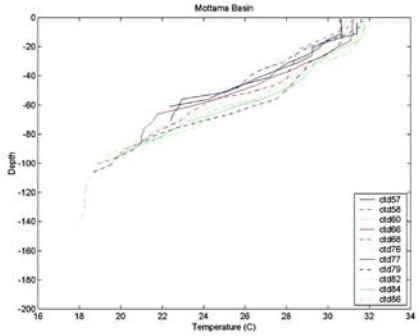


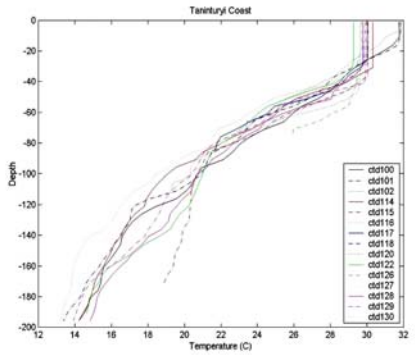
Fig.1 Zonal and Meidional wind are compared with SST
(The average SST in the middle of the basin dropped by 2°C in just 2 days after 10 May)

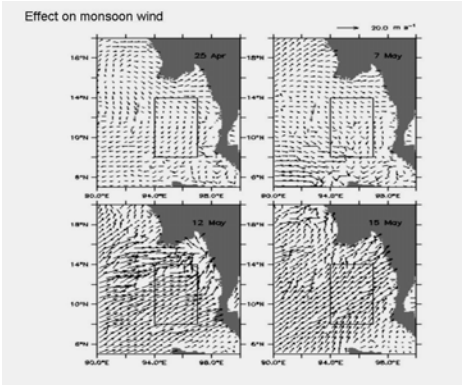




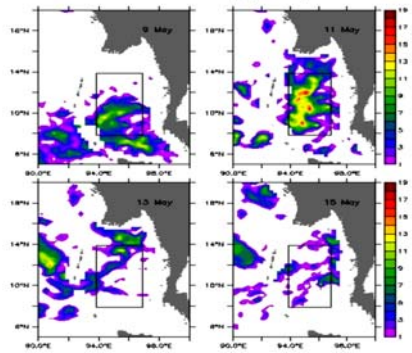




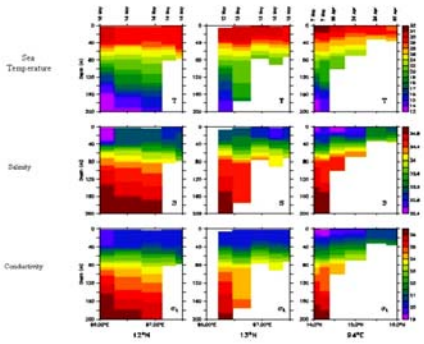




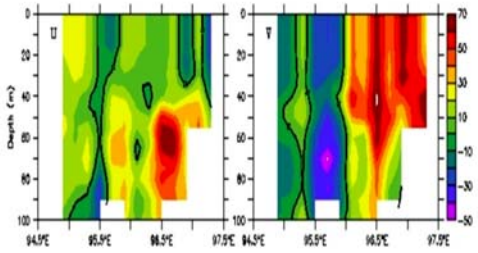
Effect on cloudiness of monsoon rain (By Satellite)

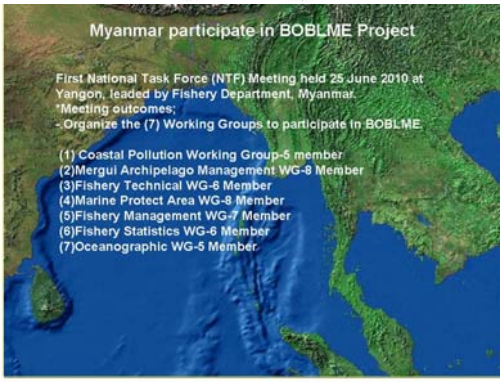


Interaction between



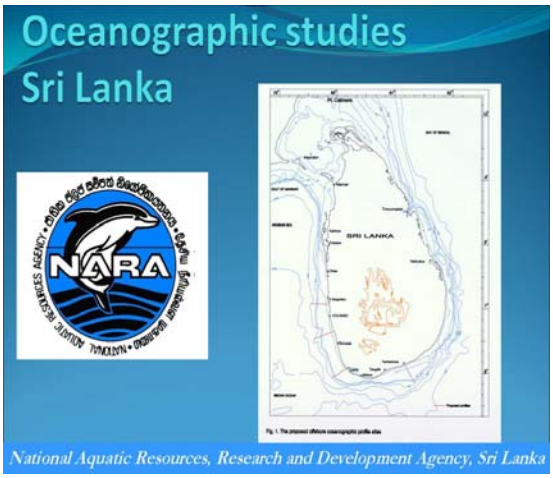
Ocean character

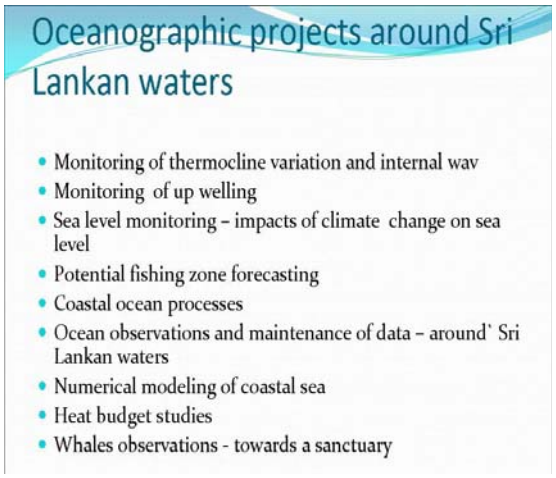


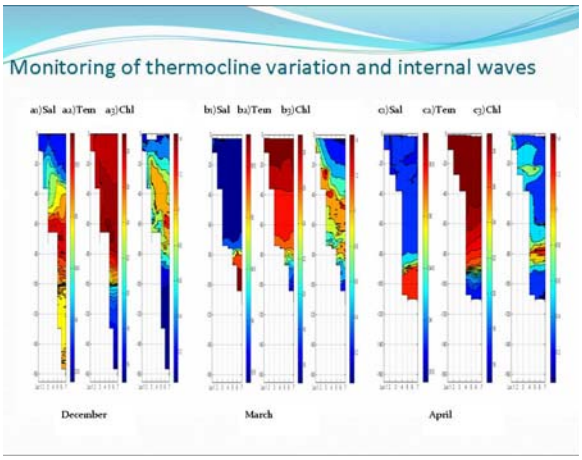


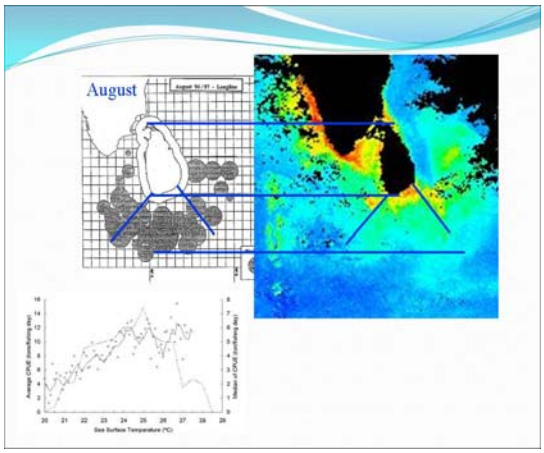
Annexure-9

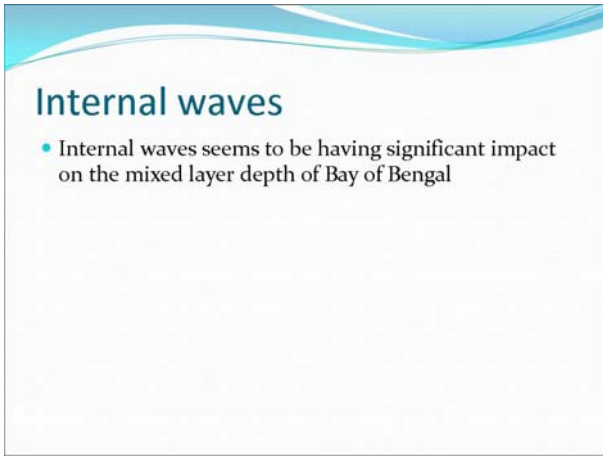
Presentation of Sri Lanka Country Report

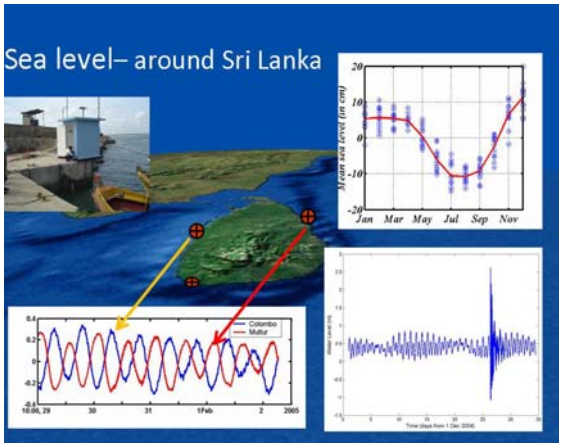








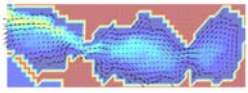




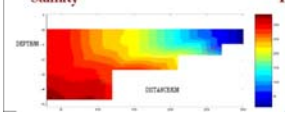
Coastal ocean processes

Comprehensive biological, physical, and chemical studies of coastal water bodies

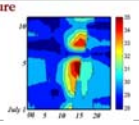
Current



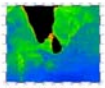
Salinity

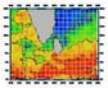


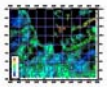
Temperature

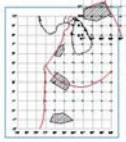


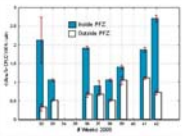
Potential Fishing Zone Forecasting







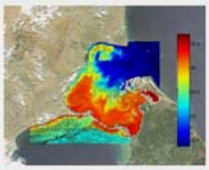


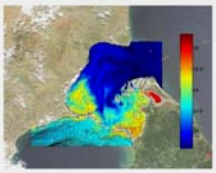


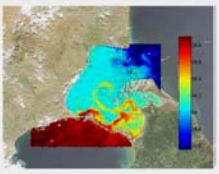
July 21, 2010

8

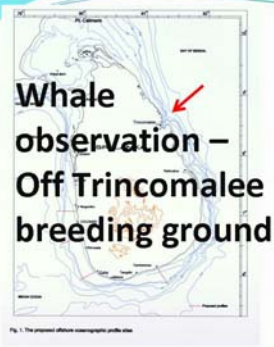
Numerical modeling of coastal waters

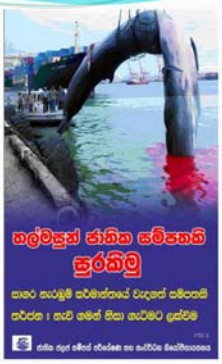






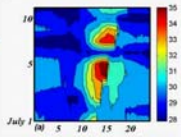
Whale observation – Off Trincomalee breeding ground

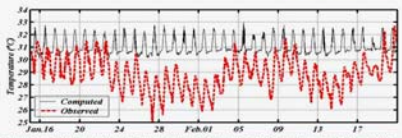




Heat budget studies

Currently limited to coastal water bodies, wish to work with north Indian ocean





Comparison of observed water temperature with predicted using atmospheric heat flux.

Requirements *(future projects)*

- Ocean status forecasting (extreme events, long term trends)
  - *Marine Weather buoy*
- Palk strait flow
  - *Sub surface buoy*
- Coastal currents & Hydrographic properties
  - *Deploy instruments to record*
- Date base management
  - *Software & training*
- Internal waves in Bay of Bengal and heat budget of north Indian ocean
  - *Software & training*
- *In situ* monitoring station - Chl a, temperature, salinity
  - *instrumentation*
- Numerical modeling on ocean processes around Sri Lanka (climate, sediment process & oil spill)
  - *Software & training*

Annexure-10

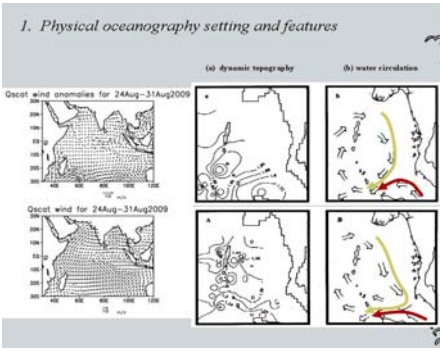
Presentation of Thailand Country Report

Oceanography and Large Scale Dynamic Processes Affecting the Bay of Bengal Large Marine Ecosystem

Thailand Overview of the Andaman Sea

Tachanat Bhatrasataponkul
Ocean-Atmosphere System Research Laboratory (OASIS)
tachanat@buu.ac.th

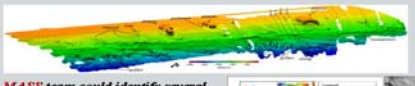
1. Physical oceanography setting and features



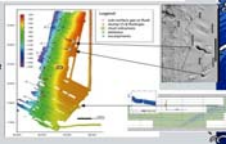
2. Overview of recent major oceanographic surveys

- *Morphodynamic and Slope Stability of Andaman Sea Shelf (MASS)*
  (Anond Snidvongs, Chulalongkorn University)
- *Ocean Reef Coupling in the Andaman Sea (ORCAS)*
  (Somkiat Khokiatiwong, Phuket Marine Biological Center)

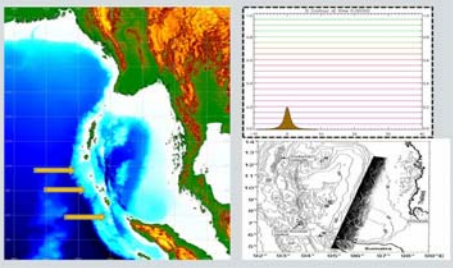
- *Morphodynamic and Slope Stability of Andaman Sea Shelf (MASS)*
  (Anond Snidvongs, Chulalongkorn University)



***MASS** team could identify several submarine morphologic systems such as sea mounts, mud volcanoes, and mudstone outcrops along the slope at depths between 500–2,000 m*



- *Ocean Reef Coupling in the Andaman Sea (ORCAS)*
  (Somkiat Khokiattiwong, Phuket Marine Biological Center)



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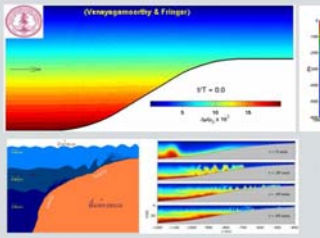

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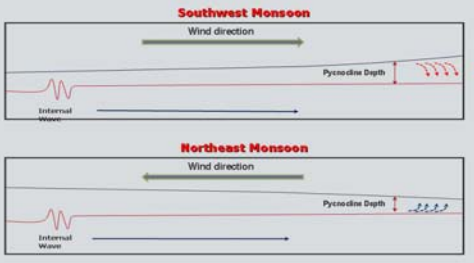

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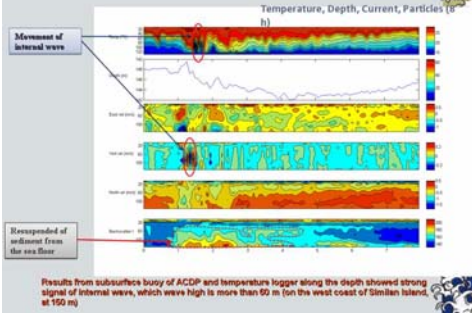
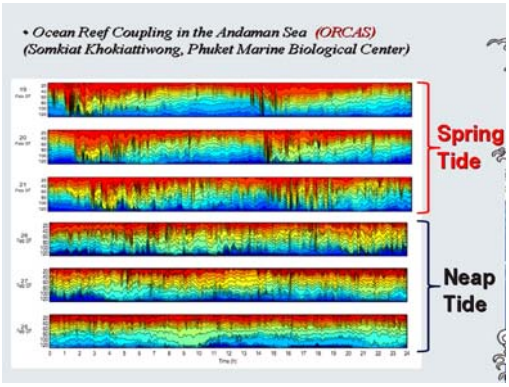
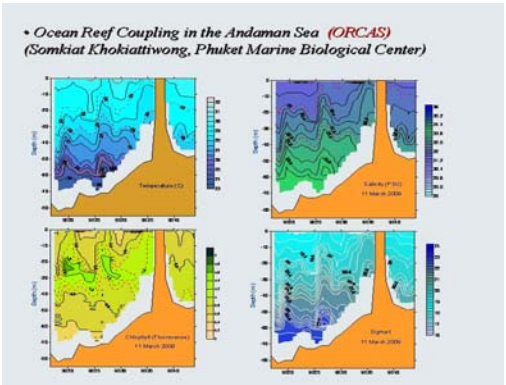



• Ocean Reef Coupling in the Andaman Sea (ORCAS)
(Somkiat Khokiattiwong, Phuket Marine Biological Center)
Spring Tide
Neap Tide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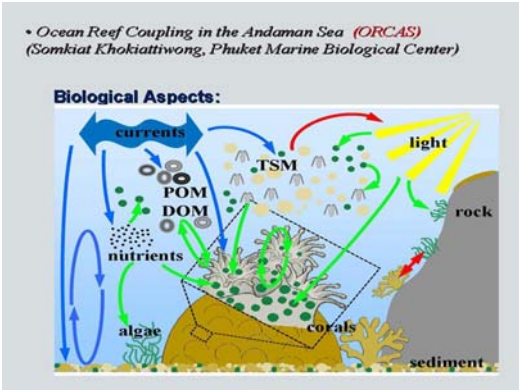
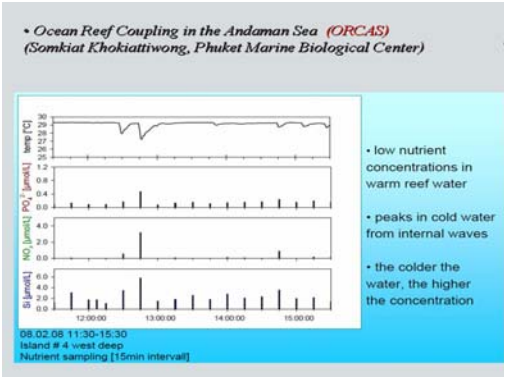
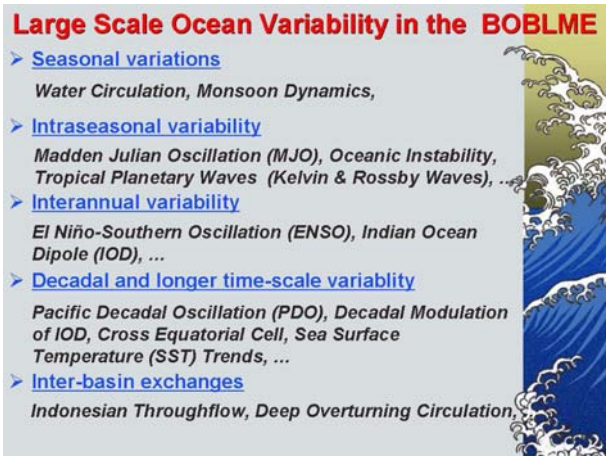

• Ocean Reef Coupling in the Andaman Sea (ORCAS)
(Somkiat Khokiattiwong, Phuket Marine Biological Center)
Biological Aspects:
currents
light
TSM
POM
DOM
rock
nutrients
algae
corals
sediment


• Ocean Reef Coupling in the Andaman Sea (ORCAS)
(Somkiat Khokiattiwong, Phuket Marine Biological Center)
• low nutrient concentrations in warm reef water
• peaks in cold water from internal waves
• the colder the water, the higher the concentration
08.02.08 11:30-15:30
Island # 4 west deep
Nutrient sampling [15min intervall]


Large Scale Ocean Variability in the BOBLME
Seasonal variations
Water Circulation, Monsoon Dynamics,
Intraseasonal variability
Madden Julian Oscillation (MJO), Oceanic Instability, Tropical Planetary Waves (Kelvin & Rossby Waves), ...
Interannual variability
El Niño-Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), ...
Decadal and longer time-scale variablity
Pacific Decadal Oscillation (PDO), Decadal Modulation of IOD, Cross Equatorial Cell, Sea Surface Temperature (SST) Trends, ...
Inter-basin exchanges
Indonesian Throughflow, Deep Overturning Circulation,

IOGOOS Workshop and Seventh Annual Meeting (IOGOOS VII)

12-16 July 2010, Perth, Western Australia

REPORT

Prepared by

Dr. V. Sampath,
Consultant, BOBLME

IOGOOS Workshop and 7th Annual meeting (IOGOSS VII)
July 12-16 2010, Perth, Western Australia

Report

The IOGOOS Workshop and the 7th Annual Meeting (IOGOOS-VII) were held during 12-16 July 2010 at Perth, Western Australia. BOBLME Regional Oceanography Workshop was also held in conjunction with the IOGOOS meeting for familiarizing the experts from the 8 BOBLME counties with the ocean observing system programmes being implemented in other parts of the Indian Ocean Region, under the auspices of IOGOOS.

A Provisional list of participants in the IOGOOS and related meetings (other than BOBLME) is at Annexure-1.

Copies of the provisional agenda for IOGOOS-7 and related meetings are at Annexure -2.

July 12, 2010 (Monday) – Day-1.

Inaugural Session

Dr Nick D'Adamo (UNESCO IOC Perth Office) welcomed the dignitaries and the delegates to the IOGOOS Workshop and presented an overview of the objectives of the week's meetings and gave a brief outline of the accomplishments of IOGOOS, IOP, IndOOS, IRF and the SIBER constituents of IOGOOS.

Dr Noel Nannup accompanied by indigenous music from Mr. Derek Nannup welcomed the delegates to the Country in a traditional way and drew the participants attention to the effects of climate change and the sea level rise along Western Australia which is over 130 metre resulting in advancement of the sea by 25 km hinterland, during a span of 5000-7000 years.

His Excellency Dr Ken Michael AC, Governor of Western Australia declared the IOGOOS VII officially open. In his address, he mentioned about the changing weather pattern and climate across the globe, land cover/land use pattern in the Indian Ocean region, drastic changes in the rainfall pattern etc., and attributed these changes to the land-sea interaction and the changing ocean conditions. He outlined the role of IOC in promoting ocean sciences, in capacity building and other compelling issues. In the area of capacity building he flagged the US initiative of involving 150 young students in Western Australia under the banner of Science Forum, to strengthen their capacity for future sustainability of the ocean environment and its resources, which faces a lot of threats from the vagaries of nature and anthropogenic pressures.

Ms. Julie de Jong, Acting Executive Director, Western Australian Department of Commerce, welcomed the dignitaries and delegates to the State of Western Australia, on behalf of the Government of Western Australia. She mentioned that Indian Ocean is a

biodiversity hotspot and climate and climate change in the Indian Ocean region is affecting agriculture, rainfall pattern, extreme weather and climatic conditions. The entire region depends on reliable ocean and meteorological observations and predictions for conserving and sustaining the resources for societal benefit.

Dr. Shailesh Naik, Secretary to the Government of India in the Ministry of Earth Sciences and the Chair, IOGOOS, in his welcome address traced the history of formation of IOGOOS and the discovery of Indian Ocean dipole which plays a major role in the global/Indian Ocean climate. Ocean controls the global climate, which is governed by the interplay between ocean, land and biosphere and it has a key role on the monsoon, cyclones, coastal erosion and so on. The ocean resources are impacted by the climate change and their conservation and sustainability require a sound system of *in-situ* and satellite based observations. Dr. Naik emphasized the need for establishment of a mechanism to continue these observations in a coordinated and concerted manner, for which he sought the support of IOC. Capacity Building in the coastal ocean observations including critical coastal habitats (coral reefs, mangroves, seagrass beds and areas of biodiversity) and coastal water quality which influences the productivity, is very essential, as the fisheries in the coastal areas are highly dependent on the water quality and nutrient and primary and secondary producers from the critical costal habitats. There is no adequate observation data on the coastal ecosystems. Uniformity in data collection, data quality and calibration are the major requirements for sustaining the ocean and coastal observations. We need to commit ourselves for making long-term observations and sustaining them over a long period of time. Sea level rise in the Indian Ocean is much faster than other regions and this aspect has to be given adequate priority in the future ocean observations, besides coastal erosion.

Dr Wendy Watson-Wright Executive Secretary IOC, in his Keynote Address highlighted the role of Global Ocean Observing System (GOOS) from the IOC perspective and related commentary on the synergistic roles of the GRAs (IOGOOS) and related project groups (IOP/SIBER/IRF) in the IOC's global context. Science, Application and Capacity Building are the three major areas addressed by IOGOOS. ICG-IOTWS is another body under the IOC to look into the Tsunami Warning System in the Indian Ocean. GOOS is a Regional Alliance which has provided important input into the whole issue of capacity building, and brings-in the requisite expertise that is required for implementing the initiatives of IOGOOS in the Indian Ocean region. Increase in the resources need to be found for funding the various initiatives that are and will be implemented under IOGOOS.

Dr. Neville Smith, Dy. Director (Research and Systems), Bureau of Meteorology, Australia, in his Keynote Address traced the events under the ocean observations and services in the Indian Ocean since SOCIO 2000. Of the 180 ocean observatories covering all the oceans in 1970s, there were only 7% in the Indian Ocean, but today it is much more. Still in real-time, we have data only up to 400 m depth and not beyond that. Ocean prediction as an observing system was initiated in the late 1990s. All the activities of IOGOOS will benefit the entire community, he said. Some of the major issues he flagged included: ***Need for a set of institutions committed on long-term Indian Ocean***

observation; and establishment of an Indian Ocean Sub-Commission, as a mechanism for the future to serve as a much broader platform for ocean science and observations.

Plenary Talks

The Keynote Plenary talk was delivered by Dr. Tim Moltmann, Director of IMOS Australi, on the topic "Australia's Integrated Marine Observing System (IMOS). Australia with the third largest ocean territory on earth is the custodian of marine assets with globally significant conservation value and is highly sensitive to the ocean influenced climate. IMOS is a national, collaborative, research infrastructure program for sustained observing in the marine environment. It seeks to integrate from open ocean, onto the continental shelf, and into the coast, integrate across physics, chemistry, and biology and make all the data discoverable and accessible for free. Established in 2007, now secure until at least 2013. Core funding of AUD 102M provided by the Australian Government with a Co-investment (in-kind and cash) of up to AUD 110M. It is a national, collaborative program led by the University of Tasmania and driven by science planning, focused in Nodes of activity on the shelf and coast, delivered by several Institutions, all operating National Facilities and makes all data discoverable and accessible for free (See Annexure - 3 for details).

Dr. Yukio Masumoto, IOP C0-Chair gave a plenary talk on the subject "IOP since IOP-6 in June 2008 and vision for the future in the context of synergies with IOP and the IRF. He highlighted the role of the Indian Ocean Science drivers, viz. Seasonal monsoons, severe weather events & cyclones, intra-seasonal (30-60 day) variations, Madden Julian Oscillation, inter-annual variations: the Indian Ocean Dipole, Influence of ENSO, decadal variability and warming trends and ocean circulations & biogeochemistry. Impacts of poditive Indian Ocean Dipole (IOD); during Austral Winter, Indian Ocean Observing System (IndOOS) – a multiplatform long-term observation network and it implementation Plan for sustained observations; present status of the various mooring arrays such as RAMA, ARGO and VOS XBT/XCTD lines, IndOOS data portal site maintained by INCOIS under cooperation with APDRC and IPRC, the science programmes using the IndOOS data, coordination of process studies such as CINDY and DYNAMO, the biogeochemical measurements under the SIBER-RAMA initiative and the IndOOS Resource Forum. He also underlined the strong linkages among IOGOOS, SIBER, IOP, and IRF – a key for full implementation of IndOOS (See detailed presentation at Annexure-4).

Another Plenary talk was delivered by Dr. Raleigh Hood, Co-chair of SIBER on "SIBER as a new science alliance under IOGOOS and IMBER and vision for the future in the context of synergies with IOP and IRF". He outlined the genesis, science plan and proposed strategic implementation plan of SIBER, which mainly has a component project for biogeochemical studies of the Indian ocean by adding an appropriate sensor to the RAMA moorings covering both Bay of Bengal and Arabian Sea (Detailed presentation at Annexure -5).

Dr. Gary Meyers, IRF Convenor, delivered a plenary talk on the Introduction to the IRF and convergence of IOGOOS, IOP and SIBER meetings towards the inaugural IRF meeting on Day 4 (15th July 2010) (See Annexure -6 for details).

Opening Session of the IOGOOS Independent meeting

Dr. Shailesh Naik, Chair, IOGOOS welcomed and complemented those involved in contributing to the activities of the IOGOOS and declared open the 7th meet. He also welcomed BOBLME to become a member of IOGOOS.

This was followed by the remarks of IOGOOS Officers, who welcomed the BOBLME Members to the meeting and invited the BOBLME to get involved in the IOGOOS activities.

Dr. Nick D'Adamo, Officer-in-Charge in the IOC-Perth Office in his remarks gave an overview of the role of IOC Perth in the IOGOOS activities, particularly the focus on developing better observing system through IOP and IndOOS framework (Annexure-7). He opined that the major activities of BOBLME can be a sub-regional programme under IndOOS and the relationship between BOBLME and IndOOS could be discussed in the next three days. Capacity development is another area under IndOOS for cooperation between developed and developing countries. INCOIS, India is running a training programme in Remote Sensing and training to the members of IndOOS on proposal writing for submission to international funding agencies. International Ocean forecasting and demonstration project is another capacity building project to bring nations together. SEAGOOS is another programme in which China, Indonesia, Malaysia and Thailand's interests are focused. The Workshop held on 9-10th July 2010 at Perth discussed in detail the outline of the science plan and project implementation plan, which will be carried forward in the next two days.

Dr. Srinivas Kumar - IOGOOS Secretary, in his remarks gave an account of the proposed ChloroGIN project in which 8 IndOOS Members are participating. This project linked with GOOS programme, will generate 1 km resolution data products and disseminate them to the IndOOS member countries. SAFARI is another major initiative funded by IOGOOS. Limited success has been achieved under the coastal ecosystem and shoreline management related activities. Mapping of mangroves, coral reef and sea grass beds is the major aspect which needs to be addressed. He also welcomed the new association of BOBLME with IOGOOS and hoped that a concrete action plan will emerge out of this association. Bangladesh has also evinced interest in joining IOGOOS.

Science Talks relevant to IOGOOS

Dr. Andreas Schiller gave a Science Talk on "Ocean Modeling for Operational Forecasting in IOGOOS Region". In his talk he emphasized the need for integrating ocean observing systems, models and application; outlined the importance of appropriate observation systems – remote sensing and in-situ observations, availability and use of appropriate operation analysis model forecast systems, Services delivery system /

dissemination and their application, impact of Remote Sensing & *in-situ* data on forecasting, SST, Sea level anomaly, etc. A multitude of multi-scale products are required by the Researchers and users, which will be a challenge and need, he said. His detailed presentation is contained in Annexure -8.

Dr. Nicolas Hoepffner, delivered a talk on "Applications of Satellite Data to Marine Ecosystem management: contribution of the SAFARI and ChloroGIN initiatives", in which he explained the objectives and outline of "ChloroGIN (Chlorophyll Global Integrated Network) project, which is "An international network for promoting ocean colour and related satellite and in water observations to assess the state of marine coastal and inland water ecosystems for the benefit of society" and SAFARI (*Societal Applications in Fisheries and Aquaculture using Remotely-sensed Imagery)* to assimilate Ecosystem Observation data into fisheries research and ecosystem-based fisheries management. He explained the capacity and training initiatives under the project and the role of INCOIS in processing data products and capacity building through training, coordinating 8 time series stations off E & W coasts of India. (Detailed presentation is given in Annexure -9).

Dr. Sidney Thurston of NOAA, Climate Program Office, gave a brief on DBCP Western Indian Capacity Building Workshop. He also outlined the goals of NOAA, which seeks to build and sustain Infrastructure to Provide Services to Benefit Society, in the areas of Observations, Forecasts, Analysis and Capacity Building. He also mentioned that as of February 2010, 62% *in-situ* networks were operational. 87% of surface observations from ships, 100% of global drifting surface buoy array, and 100% of ARGO (profiling floats) were operational. NOAA has also formal bilateral agreement with the agencies in India, Japan and Indonesia and with Agulhas Somali LME (ASCLME) comprising 9 East African countries (Planned in 2010) for IndOOS and RAMA. NOAA is also working with India and Indonesia on training, education, capacity building and ship time. (See detailed presentation in Annexure-10).

Dr. Yukio Masumoto, Japan, delivered a Science Talk in which he gave an account of the "Present status and Science highlights of the Indian Ocean Observations", which included IndOOS, Morring Arrays, IndOOS Data Portal and RAMA Data sites, the devastating cyclone Nargis from the Bay of Bengal (Apri-May 2008), MISMO observations and large-scale background conditions during the height of 2006 Indian Ocean Dipole event, etc. (See detailed presentation at Annexure- 11).

Dr. S.S.C Shenoi, Director, INCOIS, India made a presentation titled "Operational Oceanographic Services in IOGOOS Region". In his talk he highlighted the success story of the Potential Fishing Zone (PFZ) advisory provided to the fishermen, which has recently been used for developing Tuna Fishery forecasts, forecasting of the waves under the INDOFOS programme; Ocean State Forecast which includes high wave alerts, MLD, Depth of thermocline, Surface currents, sea surface temperature, etc., critical assessment of the quality of INDOFOS; Ocean Data and Information System (ODIS) and the role of INCOIS in providing these advisories to the user agencies and public. (Detailed presentation is at Annexure -12).

Dr. B.K. Jena, Scientist from NIOT, Chennai, made a presentation on the "HF Radar Network along the Indian coast under Tsunami Early Warning System (TEWS) India". HF radars are deployed at 10 locations along the Indian coastline, of which 8 are in Bay of Bengal. It plays a key role in Tsunami warning, oceanographic studies, climate research and disaster management. HF Radar Measures reflected signals from sea surface and works out surface current and Wave parameters. A pair of HF radar stations can cover about 30000 to 40000 sq. km area off-shore. These HF Radars transmit data every hour to the NIOT and INCOIS data centres. For tsunami data is received every 5 minutes. Future plan is for establishing a HF Radar network covering the entire Indian coastline (Detailed presentation at Annexure -13).

Dr. Hermes, Rudolf, Chief Technical Adviser, BOBLME made an overview presentation on BOBLME Programme. In his presentation he gave a brief history of the BOBP, recent history on the BOBLME Project development starting 2001 to date, the LME concept; the five modules of BOBLME viz. Pollution & Ecosystem Health, Productivity, Fish & Fisheries, Socio-economics and Governance, the five components of BOBLME viz. Development of an Action Plan, Resource Management, Understanding the Environment, Ecosystem Health and Communications and the details thereof. He also outlined the achievements so far, the project activities, project budget and component-wise break-up, expected project outputs and outcomes, etc. (Detailed presentation at Annexure- 14).

July 13, 2010 (Tuesday)

IOGOOS Annual Meeting

Day-2 of the IOGOOS –VII opened with an introductory remark by the Chair, IOGOOS. This was followed by remarks from Officers of IOGOOS and presentation of the progress reports on IOGOOS related activities between the 6th and the 7th IOGOOS meetings.

Dr. Nagaraja Kumar, presented the IOGOOS Secretariat Report for the period Dec. 2008 – June 2010, highlighting the action taken on various recommendations made in the 6th IOGOOS annual meeting and the progress of implementation of various activities during the interim. (A copy of the report is at Annexure -15)

Dr. Nick de' Adamo. Head, IOC-Perth Office presented the report on IOGOOS related activities (Annexure- 16). Key role of Perth Office of IOC is conducting the IOGOOS meting and making collaborative arrangements with other GOOS Regional Alliances (GRAs). IndOOS Resource Forum (IRF) is supported by Perth IOC and Dr. Gary Meyers chosen to head it. ***For consolidating the IOCs role in the Indian Ocean he suggested the formation of a Sub-commission or IGO and also include BOBLME as a Member.*** Focus should be on increasing the membership of IOGOOS. Increased involvement in disaster management, increasing management capacities, etc., are the other aspects being given adequate importance. IOC is committed to support the GRAs and before the next

annual meet of IOGOOS, a two day meet of all the members of the GRAs to be convened prior to IOGOOS meeting to prepare a plan of action/proposals for each region.

Dr. Yukio Masumoto presented a report on Indian Ocean Panel (IOP) Activities. His report highlighted the achievements/progress of Implementation of IndOOS programme, SIBER and IOP – sustained Indian ocean biogeochemical and ecological research project, IndOOS Resource Forum, Cooperation with regional/coastal observing systems. IOP tries to cooperate/coordinate With all Indian ocean regional observing systems that provide channels for application of IndOOS data, Coordinated field programmes/process studies – CINDY/DYNAMO programme led by Japanese/American scientists. Thermocline Ridge of the Indian Ocean (TRIO) initiated by Frensh Ocean community will explore air-sea interaction at synoptic (cyclone/tropical systems), intrasessionsl (Madden-Julian Oscillations) and inter-annual time scales in the 5deg S-15 deg S band of Indian Ocean (See Annexure – 17 for details).

Dr. Gary Meyers, Head of IRF presented a Report on IRF Activities/Agenda. His presentation mainly dealt with the proposed meeting of IRF on 15th July 2010 and the programme schedule (Annexure – 18).

Dr. Raiegh Hood presented a Report on SIBER Activities, which included a SIBER Conference during Ocrober 3-6, 2006 at Goa, SIBER Project Writing Workshop organized at Goa during 27-30 November 2007 which paved the way for developing six major research themes of SIBER Science Plan and its implementation components and Indian National SIBER Programme Workshop held at Goa on 13-14 April 2009, in which SIBER Research proposals were developed and presented and the structure and outline of Indian National SIBER Programme was finalised (Annexure -19).

It was noted that Dr. Shiham Adam from Maldives, who is the NC for BOBLME has been included as a Member in the proposed expanded SIBER Scientific Steering Committee. This is a welcome move and it will help in better coordination between BOBLME Members with SIBER and IOGOOS programmes in this area. Bay of Bengal will have 7 more RAMA moorings with sensors for biogeochemical observations which will cover the area between Vizag and the head Bay.

Dr. T. Srinivas Kumar, Secretary IOGOOS presented the "Report on Indian Ocean Core Remote Sensing Project", which highlighted Vision and Objectives, contents, and achievements under the ChloroGIN Project: the Indian Ocean Core Remote Sensing Project Work Plan, its components, progress under Ocean Colour (OC) Product generation, validation, Capacity building, etc (Annexure-20). He also optimistic about the opportunities for collaboration with BOBLME and SIBER.

Dr. Nick D' Adamo, IOC, Perth presented a "Report on Modeling for Ocean Forecasting and Process Studies, in which he highlighted the emergence of multiple ocean forecasting systems in IO, SEA, SW Pacific an Australian regions and IOGOOS/ocean forecasting demonstration project and also the ***BlueLink*** in December 2007. In April 2010 a Data Buoy Cooperation Panel (DBCP) Capacity Building Workshop on modeling and

observation for East South African stakeholders was held in Capetown, South Africa. Malaysia and Thailand are participating in the ecosystem modeling fisheries under SEAGOOS. Capacity building under Bluelink programme will need additional resources. (Annexure-21). On 9-10 July 2010 a Joint IOGOOS/SEAGOOS/WAGOOS/ BlueLink Australi Project Planning Workshop was held. A draft project plan covering 5 key areas viz. Cross basin (IO and SEA + West Pacific), SW Indian Ocean – Mauritius, North Indian Ocean – India, Central SEA – Malaysia. Thailand, China, Indonesia with Malaysia HQ and SE Indian Ocean (Arafura and Timor sea regions (WAGOOS), was designed and will be drafted and finalised by project group members. The proposal includes upwelling and nutritional aspects, as well. ***Indonesia needs BlueLink model for ocean forecasting system. The institution which will be a focal point has to be identified and informed.***

Dr. Nagaraja Kumar presented the Status of the following other IOGOOS Pilot projects

- Monitoring of shoreline project : drafting project proposals for 3 sub-projects of Indian ocean core RS project;
- Case studies by member countries of the project.
- Capacity Building – India, Bangladesh, Sri Lanka, Thailand and Malaysia participated in the training.

The Annual Meeting of IOGOOS also considered the Accounts and Financial summary presented by Dr. Nagaraja Kumar. This was followed by Nomination of working groups: for discussing Modelling and process studies and Remote Sensing Project; Election/Nomination/Confirmation of IOGOOS officers and IOGOOS Chair, date and venue for the next IOGOOS Annual Meeting, etc.

With this the Annual IOGOOS meeting came to a close.

13 July 2010 Post-Lunch session & 14 July 2010 – Meeting of the Break out session of Working Groups

Working Group on Modelling and process studies

I participated in the Working Group on Modelling for Ocean Forecasting and Process Studies and Dr. Rudolf Hermes, participated in the other Working Group on Remote Sensing. Dr. Andreas Schiller headed the Forecasting and Modeling Group, supported by Dr. Nick D' Adamo.

The Working Group discussed threadbare the Science Plan and Strategic implementation plan prepared on the basis of the deliberations in the Project Planning Workshop held on 9-10 July 2010 at Perth. A copy of the draft Project Plan finalised (incomplete) on 14th July 2010 is at Annexure -22.

14 Ju1y 2010 (Day-3).

Plenary – Finalisation of Work Plan and closing

Dr. Andreas Schiller briefed the Members on the progress of the Working Group on Modelling for Ocean Forecasting & Process studies. The Proposal for North Indian Ocean (India) & Central South East Asia area was completed. Proposal for South West Indian Ocean is being worked out. The exercise will be completed in consultation with the Focal points in each region, in a couple of weeks. A Workshop with IOGOOS, WESTPAC and SEAGOOS will be held in about a month, for which the timing, venue and content/schedule will be worked out and finalised.

Dr. T. Srinivas Kumar presented the progress of the Working Group on Core Remote Sensing Project. Linkage with BOBLME particularly under the Keystone ecosystem project on coral reefs, mangroves and seagrass beds, is welcome. The proposal to be prepared by Ms. Mabel Manjaji Matsumoto of Malaysia, which will be ready by end-December 2010.

Bangladesh has come forward to provide the case studies on the shoreline changes to include in the Project proposal on Shoreline Changes. Maldives is also interested in the Project. Sri Lanka will share a report on the work done in that country. The proposal on Shoreline management will be prepared in consultation with the focal points in each member country and get the proposal finalised by December 2010 (Annexure-23).

There is a possible link between BOBLME and SIBER Projects, particularly Chlorophyll a mapping project (ChloroGIN) under SIBER. BOBLME countries representatives may be invited for Capacity Building training programmes (could be funded by BOBLME). Dr. Kanthi Yapa, Sri Lanka volunteered to prepare the first draft by drawing up inputs from the ChloroGIN proposal submitted to GEO as well as inputs from the initial Participating countries and BOBLME member countries. First draft to be ready within one month (Sep 2010) and the final proposal be ready in four months (Dec 2010). The donors include GEF, EU and UNEP (Annexure -24).

Finalisation of the Work Plan and Closing of the Meeting

Invitation of Iran to host the next IOGOOS meeting was accepted.

Dr. Nick D' Adamo gave the closing comments.

Dr. M. Bhikajee – Chairman elect, IOGOOS thanked the Members for his election as the next IOGOOS Chair.

Dr. Shailesh Naik, the outgoing Chair of IOGOOS concluded the IOGOOS Annual meeting. He recalled the IOGOOS's contribution to the ocean observations in the Indian Ocean. ***It is important to note that BOBLME will be a part of this initiative.*** SIBER., IOP and IRF including the coastal ecosystem project, ocean forecasting, and ChroloGIN

have all seen a very good progress and it is very much heartening. We are all eager to cooperate with international organizations and interact with others for ocean observation globally and take and adopt the examples to Indian Ocean.

15th July 2010 (Thursday) Plenary Talks

Prof. Lyn Beazley, Chief Scientist of Western Australia gave a talk on Science in Western Australia, in which she traced the prehistoric scenario of paleoclimate, events of the Ice age, and highlighted the alliances under GOOS and IOC's role in this regard, sea level change and its impact on coastal infrastructure, the opportunities that exist for conserving/protecting mangroves, flood barriers, etc., Australian floral and coral biodiversity, fishery resources, etc., Australia's efforts in tapping wave energy, oil and natural gas, and other resources in a sustainable manner.

Dr. Srinivas Kumar, Secretary, IOGOOS presented the IOGOOS –VII summary report highlighting the proceedings of the meeting over the past three days (12-14 July 2010).

Dr. Yakio Masumoto, presented the IOP -7 report, in which he outlined the outcome of the deliberations held in the IOP meeting covering the progress under SIBER, progress in deployment of RAMA moorings and the quality of data so far collected from the moorings, ARGO floats deployment and operation and all related in-situ observation systems. He also outlined the future plans under the IOP initiatives.

Dr. Raliegh Hood, SIBER Chair presented the SIBER-1 Report. He gave a brief background on the Project and the role of SIBER and related issues. He elaborated the proposed activities under 6 major themes identified for implementation under the Science Plan. Remote Sensing, modeling, in-situ observations and potential for leveraging existing infrastructure, were all part of the exercise. He also outlined the outcome of the SIBER-1 meeting which identified a number of issues and strategies.

Dr. Gary Meyers, IRF Convener then gave an Introduction to IRF and contextual sequence to the IOGOOS, IOP and SBER reports.

The 3 day IOGOOS Workshop and IOGOOS-7 ended with a vote of thanks by the Secretary, IOGOOS and Dr. Nick D' Adamo.

At the end of the Plenary, the IndOOS Resource Forum-1 (IRF-1) meeting (by invitation only) was held.

Annexure -1.

List of Participants for the Seventh Annual meeting of Global Ocean Observing System for Indian Ocean (IOGOOS) and associated project groups

Sl. No.	Country	Participant Name and Address	Participation Role
1.	Australia	Dr Andreas Schiller (MSc PhD) Program Leader, Ocean Observation, Assessment and Prediction CSIRO Marine and Atmospheric Research Phone: 61 3 6232 5300, Fax: 61 3 6232 5000 Email: Andreas.Schiller@csiro.au	IOGOOS-7
2.	Australia	Dr. Patrick Gorringe Deputy Director, IMOS eMarine Information Infrastructure University of Tasmania, Private Bag 21, Hobart, TAS 7001, Australia Tel: +61 3 6226 8558, Fax: +61 3 6226 2997 Email: Patrick.Gorringe@utas.edu.au	IOGOOS-7
3.	Australia	Dr. Gary Meyers CSIRO Honorary Fellow Honorary Research Professor UTAS GPO Box 1538, Hobart TAS 7001, Australia 15 Browne St, Hobart TAS 7000, Australia Tel and Fax: +613 6231 9816 Email: Gary.Meyers@csiro.au	IOGOOS-7, IOP-7, IRF-1
4.	Australia	Dr. Tim Moltmann IMOS Director University of Tasmania Private Bag 110, Hobart TAS 7001 Australia T (03) 6226 2767, M 0407 558 004 Tim.Moltmann@imos.org.au	IOGOOS-7, IRF-1
5.	Australia	Dr John Keesing Stream Leader - Sustainable Coasts and Industry, CSIRO Wealth from Oceans Flagship Node Leader - Western Australian Marine Ecosystems, Western Australian Marine Science Institution CSIRO Division of Marine and Atmospheric Research Private Bag 5 Wembley 6913 AUSTRALIA Phone +61 8 93336500, Fax +61 8 93336505 Mobile 0437968766 Email: John.Keesing@csiro.au	IOGOOS-7

6.	Australia	Prof. Mervyn Lynch Professor of Remote Sensing Department of Imaging and Applied Physics Curtin University, PO Box U1987 Perth WA 6845, AUSTRALIA Email: m.lynch@curtin.edu.au	IOGOOS-7
7.	India	Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences & Government of India, Mahasagar Bhavan, Block-12, CGO Complex, Lodhi Road, New Delhi – 110 003 Tel: +91 11 24360874/ +91 11 24362548 Fax: +91 11 24362644 Email: secretary@moes.gov.in	IOGOOS-7, IRF-1,
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11.	India	Dr. Basanta Kumar Jena, Scientist E, National Institute of Ocean Technology (NIOT), NIOT Campus, Velachery – Tambaram Main Road, Narayanapuram, Pallikaranai, Chennai – 600 100, Tamil Nadu, INDIA Tel: +91 44 6678 3468; Email: bkjena@niot.res.in	IOGOOS-7
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19.	USA	Dr. Raleigh R. Hood, Professor Horn Point Laboratory University of Maryland Center for Environmental Science P.O. Box 775 Cambridge, MD 21613 phone: 410 221-8434 email: rhood@umces.edu	IOGOOS-7, IOP-7, IRF-1, SIBER-1
20.	USA	Sidney W. Thurston, Ph.D. NOAA Climate Program Office Phone: +1-301-427-2459 FAX: +1-301-427-0033 www.climate.gov Email: Sidney.Thurston@noaa.gov	IOGOOS-7, IOP-7, IRF-1

21.	IOC/ France	Dr. Wendy Watson-Wright Executive Secretary IOC, ADG of UNESCO for IOC, Intergovernmental Oceanographic Commission of UNESCO, 1 rue Miollis, 75732 Paris, Cedex 15, France Email: Tel: +33 1 45 68 39 83 Fax: +33 1 45 68 58 10	IOGOOS-7, IRF-1
22.	IOC / Australia	Dr Nick D'Adamo Officer in Charge - Perth Regional Programme Office of the Intergovernmental Oceanographic Commission (IOC), UNESCO c/- Commonwealth Bureau of Meteorology, Australia 5th floor, 1100 Hay Street (corner of Harvest Tce) West Perth 6005, Western Australia. Ph (direct) +61-8-92262899 or (reception) +61-8-92632222 Fax +61-8-92260599 Email nick.d'adamo@bom.gov.au www.ioc.unesco.org www.ioc-goos.org	IOGOOS-7, IOP-7

List of Participants for the Seventh meeting of Indian Ocean Panel (IOP-7)

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4	France	Dr. Jerome Vialard LOCEAN - Case 100 UPMC, 4, Place Jussieu 75252 Paris Cedex 05 France Phone: +33 1 44 27 70 74 Fax: +33 1 44 27 38 05 Email: jv@locean-ipsl.upmc.fr	IOP-7
5	India	Prof. Debasis Sengupta, Associate Professor, Centre for Atmospheric and Oceanic Sciences Indian Institute of Science (IISc), Bangalore, Karnataka, India. Tel: +91-80-360-0450 / +91-80-309-2505 Fax: +91-80-360-0865 Email: dsen@caos.iisc.ernet.in	IOP-7

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9	Japan	Dr. Kunio Yoneyama, Senior Research Scientist, JAMSTEC, Japan E-mail : yoneyamak@jamstec.go.jp	IOP-7
10	Japan	Dr. Weidong Yu Director, Lab. Ocean-Atmosphere Interaction and Climate Change - First Institute of Oceanography, State Oceanic Administration 6 Road Xian-Xia-Ling, High-Tech Park 266061 Qingdao, China Ph: + 86 532 88967403 Fax: +86 532 88967403 Email: wdyu@fio.org.cn	IOGOOS-7, IOP-7

11	Japan	Dr. Yukio Masumoto Sub_Group Leader, Frontier Observational Research system For Global Change, 2-15 Natsushima, Yukosuka,Kanagawa, Japan Tel: +81 468699852 Fax: +81 468619853 Email: masumoto@jamstec.go.jp	IOGOOS-7, IOP-7
12	Kenya	Dr. Charles Magori Research Officer I Kenya Marine and Fisheries Research Institute Headquater & Mombasa Station P.O. Box 81651 080100 Mombasa, KENYA Email: cmagori@kmfri.co.ke	IOP-7
13	South Africa	Dr. David Vousden Project Director, Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project, ASCLME House, 18 Somerset Street, Private Bag 1015, Grahamstown 6140 South Africa Ph: +27 46 636 2984 Fax: +27 46 622 6621 Mob: +27 79 038 6802 Email:	IOP-7, IRF-1, SIBER-1
14	UK	Dr. Kate Stansfield, Staff Scientist, International CLIVAR Project Office, National Oceanography Centre, Southampton European Way Southampton, SO14 3ZH United Kingdom Phone: 2380-596208 Fax: 2380-596204 E-Mail: k.stansfield@noc.soton.ac.uk; ks1@noc.soton.ac.uk	IOP-7

15	USA	Dr. Eric DeWeaver Assistant Professor Dept. of Atmospheric and Oceanic Sciences Center for Climatic Research University of Wisconsin - Madison 1225 West Dayton Street Madison, WI 53706 Ph: (608) 265-5438 Fax: (608) 262-0166 Email: deweaver@aos.wisc.edu	IOP-7
16	USA	Dr. Julian P. McCreary, Director, IPRC Professor of Oceanography University of Hawaii, Honolulu, Hawaii 96822 Tel: 808) 956-2216 Fax: (808) 956-9425 Email: jay@hawaii.edu	IOP-7
17	USA	Dr. Lisan Yu Associate Scientist Woods Hole Oceanographic Institution Physical Oceanography Dept., MS#21 Woods Hole, MA 02543 Ph: (508) 289-2504 Fax: (508) 457-2181 Email: lyu@whoi.edu	IOP-7
18	USA	Dr. Raleigh R. Hood, Professor Horn Point Laboratory University of Maryland Center for Environmental Science P.O. Box 775 Cambridge, MD 21613 phone: 410 221-8434 email: rhood@umces.edu	IOGOOS-7, IOP-7, IRF-1, SIBER-1
19	USA	Sidney W. Thurston, Ph.D. NOAA Climate Program Office Phone: +1-301-427-2459 FAX: +1-301-427-0033 www.climate.gov Email: Sidney.Thurston@noaa.gov	IOGOOS-7, IOP-7, IRF-1

20	USA	Dr. Tony Lee, Jet Propulsion Laboratory M/S 300-323 4800 Oak Grove Drive Pasadena, CA 91109 Ph: 818.354.1401 Fax: 818.354.0966 Email: Tong.Lee@jpl.nasa.gov	IOP-7
21	IOC	Mr Tony ELLIOTT, Head of ICG/IOTWS Secretariat, Programme Specialist, IOC/UNESCO Perth Regional Programme Office c/o Bureau of Meteorology PO Box 1370, West Perth 1100 Hay Street, Perth WA 6872 Australia, Ph: +61 8 9226 0191 Fax: +61 8 9226 0599 Email: t.elliott@unesco.org	IOP-7
22	IOC / Australia	Dr Nick D'Adamo Officer in Charge - Perth Regional Programme Office of the Intergovernmental Oceanographic Commission (IOC), UNESCO c/- Commonwealth Bureau of Meteorology, Australia 5th floor, 1100 Hay Street (corner of Harvest Tce) West Perth 6005, Western Australia. Ph (direct) +61-8-92262899 or (reception) +61-8-92632222 Fax +61-8-92260599 Email nick.d'adamo@bom.gov.au www.ioc.unesco.org www.ioc-goos.org	IOGOOS-7, IOP-7

List of Participants for the First meeting of IndOOS Resource Forum (IRF)

1.	Australia	Prof. Lyn Beazley, Invited participant Chief Scientist of Western Australia, Department of Commerce on Level 7, 1 Adelaide Terrace, East Perth, WA 6004 Tel: (08) 92638268 Email: lyn.beazley@commerce.wa.gov.au	IRF-1
2.	Australia	Dr. Greg Ayers, Invited participant Director Bureau of Meteorology (Australia), GPO Box 1289 Melbourne VIC 3001 (700 Collins Street Docklands) Tel: (03) 9669 4000 Fax: (03) 9669 4699 Email: Greg.Ayers@bom.gov.au.	IRF-1
3.	Australia	Mr. Tim Moltmann, IRF member Director Integrated Marine Observing System University of Tasmania Private Bag 110 Hobart TAS 7001 Australia Tel: (03) 6226 2767 Mob: 0407 558 004 Email: Tim.Moltmann@imos.org.au	IOGOOS-7, IRF-1
4.	Australia	Dr. Gary Meyers, IRF Convenor CSIRO Honorary Fellow Honorary Research Professor UTAS GPO Box 1538, Hobart TAS 7001, Australia 15 Browne St, Hobart TAS 7000, Australia Tel: (03) 6231 9816 Email: Gary.Meyers@csiro.au	IOGOOS-7, IOP-7, IRF-1
5.	China	Dr Zhi Chen, IRF member Director of the Division of Marine Observation, State Oceanic Administration, 1, Fuxingmenwai Avenue Beijing 100860 China Tel: +86-10 68029470 Fax: +86-10 68029470 Email: chenzhi@nmefc.gov.cn	IRF-1

6.	China	Dr. Weidong Yu, IOP Co-chair Director, Laboratory for Ocean-Atmosphere Interaction and Climate Change - First Institute of Oceanography, State Oceanic Administration 6 Road Xian-Xia-Ling, High-Tech Park 266061 Qingdao, China Ph: + 86 532 88967403 Fax: +86 532 88967403 Email: wdyu@fio.org.cn	IOGOOS-7, IOP-7, IRF-1
7.	India	Dr. Shailesh Nayak, IRF member Secretary, Ministry of Earth Sciences & Government of India, Mahasagar Bhavan, Block-12, CGO Complex, Lodhi Road, New Delhi – 110 003 Tel: +91 11 24360874/ +91 11 24362548 Fax: +91 11 24362644 Email: secretary@moes.gov.in	IOGOOS-7, IRF-1,
8.	India	Dr. SWA Naqvi, SIBER Co-chair Scientist G, Chemical Oceanography Div. National Institute of Oceanography,Dona Paula, Goa 403004, India Ph: 91-(0)832-2450294 Fax: 91-(0)832-2450607 Email: naqvi@nio.org	SIBER-1, IRF-1
9.	Indonesia	Dr Ridwan Djamaluddin, IRF member Director, Agency for the Assessment & Application of Technology (BPPT) JI.M.H. Thamrin No. 8 Jakarta Pusat Tel: +62 21-3168804 Fax: +62 21-3108149 Email: ridwan@ceo.bppt.go.id	IRF-1
10.	Japan	Dr. Shiro Imawaki, IRF member Executive Director, Japan Agency for Marine -Earth Science and Technology (JAMSTEC), 2-15, Natsushima-cho, Yokosuka-city, Kanagawa, 237-0061, Japan PHONE : +81-46-866-3811 FAX : +81-46-867-9055 Email: imawaki@jamstec.go.jp	IRF-1

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12.	Mauritius	Dr. Mitrasen Bhikajee, IRF member Director, Mauritius Oceanography Institute France Centre, Victoria Avenue Quatre-Bornes, Mauritius Voice : (230) 427 4434 Fax : (230) 427 4433 Email: bhikajee@moi.intnet.mu	IOGOOS-7, IRF-1
13.	South Africa	Dr. David Vousden, IRF member Project Director, Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project, ASCLME House, 18 Somerset Street, Private Bag 1015, Grahamstown 6140 South Africa Ph: +27 46 636 2984, Fax: +27 46 622 6621 Mob: +27 79 038 6802 Email: david.vousden@asclme.org	IOP-7, IRF-1, SIBER-1
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15.	IOC/ France	Dr. Wendy Watson-Wright, IRF member Executive Secretary IOC, ADG of UNESCO for IOC, Intergovernmental Oceanographic Commission of UNESCO, 1 rue Miollis, 75732 Paris, Cedex 15, France Tel: +33 1 45 68 39 83 Fax: +33 1 45 68 58 10 Email: w.watson-wright@unesco.org	IOGOOS-7, IRF-1

16.	IOC / Australia	Dr Nick D'Adamo, Invited participant Officer in Charge - Perth Regional Programme Office of the Intergovernmental Oceanographic Commission (IOC), UNESCO c/- Commonwealth Bureau of Meteorology, Australia 5th floor, 1100 Hay Street (corner of Harvest Tce) West Perth 6005, Western Australia. Ph (direct) +61-8-92262899 or (reception) +61-8-92632222 Fax +61-8-92260599 Email N.D'Adamo@bom.gov.au	IOGOOS-7, IOP-7
17.	USA	Prof Raleigh R. Hood, SIBER Co-chair Horn Point Laboratory University of Maryland Center for Environmental Science P.O. Box 775 Cambridge, MD 21613 phone: 410 221-8434 email: rhood@umces.edu	IOGOOS-7, IRF-1, SIBER-1
18.	USA	Dr Sidney W. Thurston, Invited participant NOAA Climate Program Office Phone: +1-301-427-2459 FAX: +1-301-427-0033 www.climate.gov Email: Sidney.Thurston@noaa.gov	IOGOOS-7, IOP-7, IRF-1

List of Participants for the First meeting of Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER)

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5.	India	Dr. SWA Naqvi, Scientist G, Chemical Oceanography Div.,National Institute of Oceanography,Dona Paula, Goa 403004, India Ph: 91-(0)832-2450294 Fax: 91-(0)832-2450607 Email: naqvi@nio.org	SIBER-1, IRF-1

6.	Japan	Dr. Hiroshi Kitazato Research Director Institute of Biogeosciences Japan Agency for Marine-Earth Science and Technology 2-15 Natsushima-cho, Yokosuka 237-0061 JAPAN TEL. 81-46-867-9767 e-mail: kitazatoh@jamstec.go.jp	SIBER-1
7.	Oman	Dr. Adnan Rashid Nasser Al-Azri Assistant Professor Department of Marine Science and Fisheries, College of Agricultural and Marine Scinces, Sultan Qaboos University, AI-Khod 123, Oman Phone: (+ 968) 2414 1254 Fax: (+ 968) 2441 3418 Email: adnazri@squ.edu.om	SIBER-1
8.	South Africa	Dr. David Vousden Project Director, Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project, ASCLME House, 18 Somerset Street, Private Bag 1015, Grahamstown 6140 South Africa Ph: +27 46 636 2984 Fax: +27 46 622 6621 Mob: +27 79 038 6802	IOP-7, IRF-1, SIBER-1
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10.	USA	Dr. R. Dwi Susanto Research Scientist/Director Indonesian Research Coordination, Lamont Doherty Earth Observatory of Columbia University 61 Route 9W, Palisades, New York 10964. Ph. 1-845-365-8545; Fax: 1-845-365-8157; E-mail: dwi@ldeo.columbia.edu	SIBER-1
11.	USA	Dr. Jeery Wiggert, Assistant Professor Department of Marine Science 1020 Balch Blvd. Stennis Space Center, MS 39529-9904 Ph: 228-688-3491 Fax: 228-688-1121 Email: jerry.wiggert@usm.edu jwiggert@ccpo.odu.edu	SIBER-1
12.	USA	Dr. Raleigh R. Hood, Professor Horn Point Laboratory University of Maryland Center for Environmental Science P.O. Box 775 Cambridge, MD 21613 phone: 410 221-8434 email: rhood@umces.edu	IOGOOS-7, IRF-1, SIBER-1
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15.		Dr. David Holliday PhD Candidate School of Environmental Science Marine Management Research Group Murdoch University South St, Murdoch Western Australia 6150 Phone: (61) 08 9239 8807	

Annexure-2

Integrated schedule for IOGOOS-7, IOP-7, SIBER-1, IRF-1. Perth, Western Australia, Monday-Friday, 12-16 July 2010.
Draft 22 March 2010.

Mon 12 July		**Tue 13 July**	**Wed 14 July**	**Thur 15 July**	**Fri 16 July**	**Sat/Sun 17/18 July**
IOGOOS IOP SIBER	IOGOOS, IOP SIBER	IOGOOS, IOP SIBER	IOGOOS, IOP, SIBER	IOGOOS, IOP, SIBER + IRF	IOGOOS, IOP SIBER + IRF?	
AM 0845 To 1200 **Joint opening** **IOGOOS** **+** **IOP** **+** **SIBER** . Intro & welcome speeches. Plenary talks by Invited dignitaries. & Plus plenary talks by IOGOOS, IOP, & SIBER, and IRF leaders.	PM **IOGOOS, IOP, SIBER run their own meetings** EVENING 1800-1930 Ice breaker event	ALL DAY **Continued - IOGOOS, IOP, SIBER run their own meetings** EVENING free time	0900-1400 **Continued - IOGOOS, IOP, SIBER run their own meetings** AFTERNOON 1400-1800 **Networking event.** For IOGOOS, IOP, SIBER + IRF delegates EVENING 1930-2230 **Conference dinner** (venue to be advised) For IOGOOS, IOP, SIBER + IRF delegates Hopefully the afternoon and evening events will include IRF members who would arrive in Perth during the night before or during the morning of Wed 14 July	0900-1030 **Reporting by IOGOOS, IOP, SIBER** MID-MORNING TO CLOSE 1100-1630 **IRF-1 meeting, in conjunction with reps from IOGOOS, IOP and SIBER**	ALL DAY **Discussion by IOP, SIBER, IOGOOS, CLIVAR, and IOC Perth representatives regarding development of actions in response to the IRF-1 meeting of Thursday 15 July.** **Some IRF members may wish to be present for these discussions.**	**OPTIONAL** **Social opportunity.** **Western Australian post-meeting tourism options can be sourced through Western Australia's official tourism website.** **www.westernaustralia.com** **Not sponsored.**

PROVISIONAL AGENDA FOR 12-16 JULY 2010

MONDAY 12 JULY

Opening schedule

0845-1030

Introduction by Dr Nick D'Adamo (UNESCO IOC Perth Office)

Welcome to Country by Dr Noel Nannup (accompanied by Indigenous music from Derek Nannup).

Official Opening by His Excellency Dr Ken Michael AC, Governor of Western Australia.

Welcome on behalf of the State of Western Australia by Julie de Jong, Acting Executive Director, Western Australian Dept. of Commerce, representing Hon. Bill Marmion, MLA, Govt. of Western Australia.

Welcome on behalf of IOGOOS by Dr. Shailesh Nayak, Chair, IOGOOS: Secretary, Ministry of Earth Sciences, India

Keynote Address by Dr Wendy Watson-Wright. Executive Secretary IOC, Asst. Director General, UNESCO. *GOOS from the IOC perspective and related commentary on the synergistic roles of the GRAs IOGOOS / IOP / SIBER / IRF in the IOC's global context.*

Keynote address by Dr Neville Smith. Dy. Director (Research and Systems), Bureau of Meteorology, Australia. *The past 10 years: ocean observations and services in the Indian Ocean since SOCIO 2000".*

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1030-1100: MORNING TEA break

Plenary Talks 1100-1200 hrs

1100-1115
Keynote Plenary Talk by Director of IMOS Australia, Tim Moltmann. ***Australia's Integrated Marine Observing System.***

1115-1130
Plenary Talk by Dr Yukio Masumoto & Dr Weidong Yu, IOP Co-Chairs. ***IOP since IOP-6 in June 2008 and vision for the future in the context of synergies with SIBER and the IRF*****.**

1130-1145
Plenary Talk by Professor Raleigh Hood, SIBER Chair. ***SIBER as a new science alliance under IOGOOS and IMBER and vision for the future in the context of synergies with IOP and the IRF*****.**

1145-1200
Plenary Talk by Dr Gary Meyers, IRF Convenor. ***Introduction to the IRF, and convergence of the IOGOOS, IOP and SIBER meetings towards the inaugural IRF meeting on Day 4 (Thursday 15 July 2010).***

1200-1330
LUNCH

1330-1630
IOGOOS, IOP, SIBER meet independently.

1500-1530
AFTERNOON TEA

TUESDAY 13 JULY

IOGOOS, IOP, SIBER meet independently.

1015-1045
MORNING TEA

1200-1330
LUNCH

1500-1530
AFTERNOON TEA

WEDNESDAY 14 JULY

0900-1400
IOGOOS, IOP, SIBER meet independently.

1015-1045
MORNING TEA

1200-1330
LUNCH

1400-1800
Social / networking outing. Caversham Wildlife Park (to be confirmed). All groups.

1930-2230
Conference dinner. DETAILS TO BE ADVISED.

THURSDAY 15 JULY

0900-0920
Plenary Talk by Dr Gary Meyers, IRF Convenor. IRF members present. ***Introduction to IRF and contextual segue to the IOGOOS, IOP and SIBER reports.***

0920-0940
Plenary Talk by DR Shailesh Nayak, IOGOOS Chair. ***IOGOOS-7 Report.***

0940-1000 Plenary Talk by Dr Yukio Masumoto and/or Dr Weidong Yu, IOP Co-Chairs. ***IOP-7 Report.***

1000-1020
Plenary Talk by Professor Raleigh Hood, SIBER Chair. ***SIBER-1 Report.***

1020-1100

EXTENDED MORNING TEA for IOGOOS, IOP and SIBER delegates

1040-1100
IRF meet in camera to formally elect a Chair

1100-1200
IRF-1 meeting (including selected representatives from IOGOOS, IOP and SIBER).

1200-1330
LUNCH

1330-1630
IRF-1 meeting.

1500-1530
AFTERNOON TEA

FRIDAY 16 JULY

Tentative

Discussion by IOP, SIBER, IOGOOS, CLIVAR, and IOC Perth representatives regarding development of actions in response to the IRF-1 meeting of Thursday 15 July. (by Invitation only).

Some IRF members may wish to be present for these discussions.

Annexure-2 (Cont..)

IOP-7 MEETING
12-14 July 2010, Perth, Australia

Draft Agenda (Jun. 14, 2010)

Participants:
IOP members: Ming Feng, Raleigh Hood, Gary Meyers, Tony Lee, Charles Magori, Yukio Masumoto, Jay McCreary, VSN Murty, Fadli Syamsudin, Jerome Vialard, Lisan Yu, Weidong Yu, Debasis Sengupta
(Apology for absence: Mike McPhaden, Gabe Vecchi, Will de Ruijter)
Invited experts: Kunio Yoneyama, Sidney Thurston, Tony Elliott, Harry Hendon, Ken Ando, David Vousden, M. Ravichandran
Observer: Eric DeWeaver
ICPO staff: Kate Stansfield
IOC Perth Office: Nick D'Adamo

IOP-7 will be held in conjunction with IO-GOOS and SIBER-SSG meetings, which are followed by the first IndOOS Resource Forum (IRF) on 15 July.

DAY-1 (Monday July 12) Morning

Plenary session with IO-GOOS and SIBER

DAY-1 (Monday July 12) Afternoon [13:00 – 17:00]

- Welcoming by patrons (*K. Stansfield*)
- Self-introduction
- Review of the agenda and Action Items *(Y. Masumoto and W. Yu)*
- Report on SSG-17 *(Y. Masumoto)*

UPDATES ON INDOOS AND RECENT SCIENCE-RESULTS FROM THE DATA STREAMS [13:30-15:00]
- RAMA *(Inputs from M. McPhaden, VSN Murty, K. Ando, W. Yu) [~ 1 hr]*
- Argo float status in the IO and the IndOOS Data Portal (*M. Ravichandran*) *[30min]*

15:00-15:30 AFTERNOON TEA

UPDATES ON INDOOS AND RECENT SCIENCE-RESULTS FROM THE DATA STREAMS (cont.) [15:30-15:50]
- XBT Network (*G. Meyers and VSN Murty*) *[20min]*

ENHANCEMENT OF INDOOS [15:50-17:10]
- Australian contribution to RAMA (*M. Feng or G. Meyers*) [20min]
- Air-Sea heat, freshwater and momentum fluxes in the Indian Ocean (*L. Yu)* [20min]
- IOTWS: current status and future plans (*Tony Elliott*) [20min]
- Discussions about issues of IndOOS implementation (*all*) [20min]

(Enhancement for biogeochemical observations would be discussed at "possible cooperation between SIBER and IOP" session)

18:00-19:30 Ice breaker

DAY-2 (Tuesday July 13) [9:00-17:00]

COORDINATION OF MULTINATIONAL PROCESS STUDIES [9:00-10:15]
- CINDY/DYNAMO (*K. Yoneyama*) [30min]
- Australian contribution to CINDY/DYNAMO (*H. Hendon*) [20min]
- TRIO project plans (*J. Vialard*) [20min]

10:15-10:45 MORNING TEA

INDOOS RESOURCES FORUM (IRF) [10:45-11:45]
- Status of IRF and review of the IRF agenda (*G. Meyers*) [30min]
- Discussions about IOP inputs to IRF [30min]

SCIENCE TALK (1) [11:45-12:00]
- Charles Magori [15min]

12:00-13:30 Lunch

Possible cooperation between SIBER and IOP (Joint with SIBER) [13:30-15:00]

1330-1345
SCIENCE TALK: *SIBER Science Plan recommendations for biogeochemical sensor deployments in the Indian Ocean*: *Progress since IOP-6* (Raleigh Hood)

1345-1400
SCIENCE TALK: *Report on the status of IndOOS* (Gary Meyers)

1400-1415
SCIENCE TALK and NATIONAL PERSPECTIVE: *India's Mooring-time series, Argo floats and deployment of biogeochemical sensors* (M. Ravichandran, TO BE CONFIRMED)

1415-1430
SCIENCE TALK and NATIONAL PERSPECTIVE: *JAMSTEC, NOAA and FIO plans for deployment of CO_2 and other biogeochemical sensors. Should IOP/SIBER consider a joint training workshop to ensure the unified standards and data processing?* (Weidong Yu, Yukio Masumoto, Ken Ando)

1430-1500
PROGRAM OVERVIEW AND DISCUSSION: *IndOOS/RAMA, the potential for deploying biogeochemical sensors, and establishing linkages with SIBER* (Leaders: Gary Meyers and Raleigh Hood)

15:00-15:30 AFTERNOON TEA

REGIONAL ISSUES [15:30-17:30]
- LOCO, Agulhas Current monitoring, and SCOR Agulhas WG (*Y. Masumoto for W. de Ruijter*) [20min]
- ASCLME (*D. Vousden, To be confirmed*) [20min]
- Western Australia IMOS (*M. Feng*) [20min]
- Indian moorings in Bay of Bengal and Arabian Sea (*VSN. Murty)* [20min]

- Joint IOGOOS/SEAGOOS pilot project titled: *Ocean Forecast Demonstration projects in IOGOOS and SEAGOOS* (M. Bhikajee, *N. D'Adamo, To be confirmed*)
- Monsoon Onset Monitoring and its Social and Ecosystem Impacts (MOMSEI) (*W. Yu*) [10 minutes]

19:00 Panel meeting dinner

DAY-3 (Wednesday July 14) Morning [9:00-12:00]

SCIENCE TALK (2) [9:00-9:45]
- Three talks (TBD) [15min each]

RELATED ACTIVITIES: [9:45-10:15]
- NOAA bilateral programs in the region (*Sid Thurston*)
- ITF-TF (*Y. Masumoto*)
- CLIVAR IOD Workshop (*Y. Masumoto*)

10:15-10:45 MORNING TEA

RELATED ACTIVITIES: [10:45-11:15]
- Discussion on IOP contribution to the CLIVAR future directions (IO review paper?)
- WCRP Open Science Conference

Panel Business: [11:15-12:00]
- Wrap-up discussion *(all panel)*
- Identify action items
- Membership and Next meeting *(all panel)*

12:00-13:30 Lunch

14:00-18:00
Social / networking outing. Caversham Wildlife Park (to be confirmed). All groups.

19:30-22:30
Conference dinner.

Agenda (draft)
Indian Ocean Observing System (IndOOS) Resources Forum
Thursday 15 July 2010 Citigate Hotel, Perth, Australia

Plenary Session with IOGOOS, IOP, SIBER and IRF

0900-0920 Plenary Talk by Chief Scientist of Western Australia
0920-0940 Plenary Talk by IOGOOS Chair. *IOGOOS-7 Report.*
0940-1000 Plenary Talk by IOP Chair. *IOP-7 Report.*
1000-1020 Plenary Talk by SIBER Chair. *SIBER-1 Report.*
1020-1030 Plenary Talk by IRF Convenor. *Introduction to IRF*

1030-1100 Morning tea

1100-1700 First meeting of the IndOOS Resources Forum (by invitation members and observers)

1. 1100-1115 Welcome and Introductions (15 min)
2. 1115-1200 IRF business (45 minutes)
   --Elect chairman, approve agenda
   --Discuss and revise terms of reference, objectives and modus operandi
3. 1200-1245 IRF members briefly describe contributions to IndOOS and interests in observing the Indian Ocean from a personal, or agency-, or national perspective (45 minutes)

1245-1400 Lunch

4. 1400-1420 Presentation and discussion of societal benefits from IndOOS (20 minutes)
5. 1420-1440 Presentations to recap--key science issues and future resource-needs
   1420-1440 Chair Indian Ocean Panel (10 minutes)
   1440-1500 Chair SIBER (10 minutes)
6. 1440-1500 Convenor discussion of the resources needed by IndOOS (20 min)

1500-1530 Afternoon tea

7. 1530-1700 Round table discussion of resourcing issues (90 minutes)
   --Sustaining the RAMA climate array: Ship-time is a critical challenge. Members will brief the Forum on how ship time is allocated in each country and agree common action.
   --Enhancement of RAMA with biogeochemical sensors
   --Other issues (IRF members invited to raise issues)
8. 1700-1715 Next meeting, review of post-meeting actions, closing (15 min)

Participants

IRF members

Bhikajee, Mitrasen: Director Mauritius Oceanography Institute (Mauritius)
Chen, Zhi: Director: Office of Ocean Observation SOA (China)

Imawaki, Shiro: Executive Director JAMSTEC (Japan)
Majodina, Mark: Manager of International Relations SAWS (S. Africa)
Moltmann, Tim: Director Integrated Marine Observing System (Australia)
Nayak, Shailesh: Secretary Ministry of Earth Sciences (India)
Ridwan, Djamaluddin: Director Environmental Services BPPT (Indonesia)
Vousden, David: Director Agulhas and Somali Current Large Marine Ecosystems (International)
Watson-Wright, Wendy: Assistant Director General UNESCO, Executive Secretary IOC

Apologies from members

Koblinsky, Chet*: Director Climate Program Office NOAA (USA)
Lin, Shanqing: Director General, Department of Ocean Forecast and Disaster Mitigation (China)
Monfray, Patrick**: Directeur-adjoint de l'Institut National des Sciences de l'Univers (France)
Ruellan, Etienne**: Technical Division INSU (France)
* Will join by video-conference in the morning
** Will join by video-conference in the afternoon

Convenor

Meyers Gary Honorary Fellow CSIRO and University of Tasmania (Australia)

Observers

Ayers, Greg: Director Bureau of Meteorology (Australia)
Beazley, Lyn Chief Scientist of Western Australia
D'Adamo, Nick: Head IOC Perth Regional Program Office (International)
Hood, Raleigh: Co-Chair Sustained Indian Ocean Biogeochemical and Ecological Research
Masumoto, Yukio: Co-chair CLIVAR-GOOS Indian Ocean Panel
Naqvi, Wajih: Co-Chair Sustained Indian Ocean Biogeochemical and Ecological Research
Thurston, Sidney: International Coordinator Climate Program Office NOAA (USA)
Yu, Weidong: Co-chair CLIVAR-GOOS Indian Ocean Panel

SIBER - Scientific Steering Committee Meeting July 12-15, 2010, Perth Australia

Final Agenda

Interim Steering Committee Members:

Raleigh Hood
Wajih Naqvi
Jerry Wiggert
Tim Rixen
Mike Landry (not attending)
Catherine Goyet
Adnan Al-Azri
David Vousden
Richard Matear (for Lynnath Beckley)
Greg Cowie
Hiroshi Kitazato
Dwi Susanto

MONDAY 12 JULY

1330-1345
SIBER SSC WELCOME: *Introductions, overview of agenda and meeting goals* (Raleigh Hood and Wajih Naqvi)

1345-1400
KEYNOTE ADDRESS BY INDIA'S EARTH SCIENCE SECRETRY, DR. SHAILESH NAYAK: *How India can help coordinate and implement international SIBER activities.* CONFIRMED.

1400-1415 NATIONAL PERSPECTIVE: *SIBER India: Proposals, progress and plans* (Wajih Naqvi)

1415-1445
DISCUSSION: *How can India help coordinate and implement international SIBER activities? Can a SIBER program office be established in India?* (Leaders: Wajih Naqvi and Raleigh Hood)

1445 -1500
SCIENCE TALK: *The SIBER Science Plan and research themes, peer review recommendations, and finalization progress* (Raleigh Hood)

1500-1530
AFTERNOON TEA

1530-1545
SIBER BUSINESS: *Nomination and Election of SIBER SSC officers (Chair, co-Chair and Secretary) and discussion of proposed new SSC members, rotations etc.* (Leaders: Raleigh Hood and Wajih Naqvi)

1545-1600
SIBER BUSINESS CONTINUED: *Establishing Working Groups, Working Group Chairs and Working Group Goals. Should these revolve around the SIBER research themes as proposed in the SIBER Science Plan and/or regional/national interests?* (Leaders: Raleigh Hood and Wajih Naqvi)

1600-1615
SCIENCE TALK: *Oxygen deficiency in the North Indian Ocean* (Wajih Naqvi)

1615-1630
SUMMARY OF THE DAYS PRESENTATIONS AND DISCUSSIONS: *Formulation of recommendations and action items* (SIBER Secretary)

1830-2130 SIBER Dinner. DETAILS TO BE ADVISED.

TUESDAY 13 JULY

0845-0850
Introductions and review of agenda for the day (Raleigh Hood and Wajih Naqvi)

0850-0915
SIBER BUSINESS: *Establishing a SIBER website and newsletter* (Leaders: Jerry Wiggert, Wajih Naqvi and Raleigh Hood)

0915-0930
NATIONAL PERSPECTIVE: *Indonesia and potential linkages to SIBER* (Dwi Susanto)

0930-0945
NATIONAL PERSPECTIVE: *Africa, the ASCLME and potential linkages to SIBER* (David Vousden)

0945-1000
NATIONAL PERSPECTIVE: *Oman and potential linkages to SIBER* (Adnan Al-Azri)

1000-1015
DISCUSSION: *Promoting SIBER in IO rim nations, particularly Indonesia, Africa and Oman. How do we get SIBER established in these countries?* (Leaders: David Vousden, Dwi Susanto, and Adnan Al-Azri)

1015-1045
MORNING TEA

1045-1100
DISCUSSION CONTINUED: *Promoting SIBER in IO rim nations, particularly Indonesia, Africa and Oman. How do we get SIBER established in these countries?* (Leaders: David Vousden, Dwi Susanto, and Adnan Al-Azri)

1100-1115
SCIENCE TALK and NATIONAL PERSPECTIVE: *German research in the Indian Ocean: Past and future perspectives* (Tim Rixen)

1115-1130
SCIENCE TALK and/or NATIONAL PERSPECTIVE: *French contributions to the study of the Indian Ocean carbon cycle* (Catherine Goyet)

1130-1200
DISCUSSION: *Strategies for tying SIBER into global carbon cycle research programs* (Leaders: Catherine Goyet and Tim Rixen)

1200-1330
LUNCH
TUESDAY 13 JULY CONTINUED Convene Joint SIBER/IOP Session

1330-1345
SCIENCE TALK: *SIBER Science Plan recommendations for biogeochemical sensor deployments in the Indian Ocean*: *Progress since IOP-6* (Raleigh Hood)

1345-1400
SCIENCE TALK: *Report on the status of IndOOS* (Gary Meyers)

1400-1415
SCIENCE TALK and NATIONAL PERSPECTIVE: *India's Mooring-time series, Argo floats and deployment of biogeochemical sensors* (M. Ravichandran, TO BE CONFIRMED)

1415-1430
SCIENCE TALK and NATIONAL PERSPECTIVE: *JAMSTEC, NOAA and FIO plans for deployment of CO_2 and other biogeochemical sensors.* (Weidong Yu, Yukio Masumoto CONFIRMED, and Ken Ando TO BE CONFIRMED)

1430-1500
PROGRAM OVERVIEW AND DISCUSSION: *IndOOS/RAMA, the potential for deploying biogeochemical sensors, and establishing linkages with SIBER* (Leaders: Gary Meyers and Raleigh Hood)

1500-1530
AFTERNOON TEA (Close Joint SIBER/IOP Session)

1530-1545
SCIENCE TALK: *Use of newly developed ocean color algorithms to assess the Indian Ocean dipole's impact on regional to basin scale biogeochemical fluxes* (Jerry Wiggert)

1545-1600
SCIENCE TALK and NATIONAL PERSPECTIVE: *Brief report from the Arabian Sea OMZ dive cruise (YK08-11) and the current research plan for the Indian Ocean by JAMSTEC* (Hiroshi Kitazato)

1600-1615
SCIENCE TALK and NATIONAL PERSPECTIVE: *Benthic process studies in the Indian Ocean: Recent studies in the Arabian Sea, and opportunities for the future* (Greg Cowie)

1615-1630
DISCUSSION: *Developing strategies for getting developed nations in Europe, Asia and North America engaged in SIBER* (Leaders: Greg Cowie and Hiroshi Kitazato)

1630-1700 SUMMARY AND RECOMMENDATIONS (SIBER Secretary)

Dinner on your own.

WEDNESDAY 14 JULY

0845-0850
Introductions and review of agenda for the day (Raleigh Hood and Wajih Naqvi)

0850-0915
SIBER BUSINESS: *Funding availability from IMBER and IOGOOS for future SIBER events and activities. National support needs to be established.* (Raleigh Hood and Nick D'Adamo)

0915-0945
PROGRAM OVERVIEW AND DISCUSSION: *Strategies for developing meaningful linkages and synergies between SIBER, IOP, IOGOOS and IMBER* (Leaders: Nick D'Adamo, Raleigh Hood and Wajih Naqvi)

0945-1000
SCIENCE TALK: *Recent biophysical research in the Leeuwin Current system* (Ming Feng, CONFIRMED)

1000-1015
SCIENCE TALK: *Primary production in the Leeuwin Current* (Christine Hanson, CONFIRMED)

1015-1045
MORNING TEA

1045-1100
SCIENCE TALK: *Impacts of Leeuwin Current eddies on cross-shelf transport of fish larvae* (David Holliday, CONFIRMED)

1100-1115
SCIENCE TALK: *Modeling with BlueLINK in the Indian Ocean* (Richard Matear)

1115-1130
SCIENCE TALK: *The Western Australia node of IMOS* (Chari Pattiaratchi, CONFIRMED)

1130-1200
NATIONAL PERSPECTIVE AND DISCUSSION: *Australia, BlueLINK, the IMOS Program and potential linkages to SIBER. Can a SIBER Program office be established in Australia?* (Leader: Richard Matear and Gary Meyers, CONFIRMED)

1200-1330
LUNCH

WEDNESDAY 14 JULY CONTINUED

1330-1400
SUMMARY OF PRESENTATIONS AND DISCUSSION: *Formulation of final recommendations and action items and development of SIBER SSC meeting reports and products* (Leaders: SIBER Secretary, Raleigh Hood and Wajih Naqvi)

1400-1800 Adjourn. *Social outing. Caversham Wildlife Park. All groups.*

1930-2230 Conference Dinner.

Annexure-3

Keynote Plenary Talk by Dr. Tim Moltmann

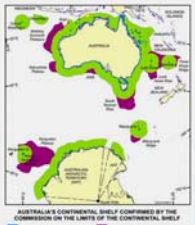
IMOS Integrated Marine Observing System

The Australian

Integrated Marine Observing System

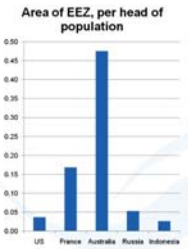
1. Australia is a 'marine nation'

- We have the third largest ocean territory on earth
- We are highly sensitive to our ocean-influenced climate
  - *drought, flood, extreme events*
- We extract huge economic benefit from our ocean territory
  - *marine tourism, oil and gas, shipping, fishing & aquaculture*
- We are custodians of marine assets with globally significant conservation value
  - *from the high tropics to Antarctica*



2. An opportunity, and a challenge

- This ocean territory represents a great opportunity for the Australian people
- But it also represents a great challenge...
- It is not easy to observe, understand and manage such a vast ocean territory, with a relatively small (though prosperous) population

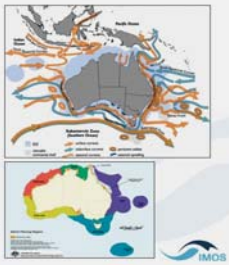


3. Clearly, we must collaborate

- Globally,
  - *through initiatives such as GOOS*
- Regionally,
  - *through initiatives such as IOGOOS*
- and Nationally
  - I will talk briefly about a major initiative in Australia
  - designed to strengthen our national approach to sustained ocean observing
  - within the regional/global context

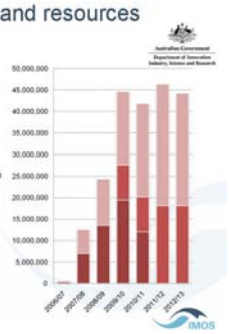
4. IMOS, Australia's Integrated Marine Observing System

- IMOS is a national, collaborative, research infrastructure program..
- ...for sustained observing in the marine environment
- It seeks to integrate from open ocean, onto the continental shelf, and into the coast
- It seeks to integrate across physics, chemistry, and biology
- And make all the data discoverable and accessible for free



5. IMOS timeframe and resources

- Established in 2007, now secure until at least 2013
- Core funding of AUD 102M provided by the Australian Government
  - Co-investment (in-kind and cash) of up to AUD 110M
- Now planning to sustain IMOS over the long term, noting that...
  - It provides research infrastructure
  - It doesn't fund research projects
  - It's not an operational system



6.–11. Key features of IMOS

(next six slides)

6. A national, collaborative program
7. Driven by science planning
8. Focused in Nodes of activity on the shelf and coast
9. Delivered by several different Institutions, all operating National Facilities

10-11. Makes all data discoverable and accessible for free

6. IMOS, national and collaborative

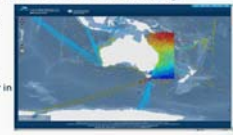
- The program is led by the University of Tasmania
  - *on behalf of the whole marine and climate science community*
- Major institutions around the nation own and operate components of the system
  - *institutional strengths/expertise, available to all the community*
- All must make data available to the whole community
  - *condition of contract*

7. IMOS, driven by science planning

- Decisions about what to observe, and where, are driven by Science Plans addressing five major research themes
  - Multi-decadal Ocean Change
  - Climate Variability and Weather Extremes
  - Major Boundary Currents and Inter-basin Flows
  - Continental Shelf Processes
  - Biological Responses
- Science Plans are being internationally peer reviewed

8. IMOS, focused in Nodes of activity

- Blue-water and Climate Node
  - open ocean focus
  - broad scale
  - recognising Australia's role as a key southern hemisphere partner in international programs



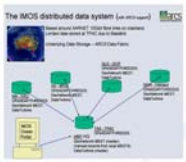
- Five Regional Nodes focused on shelf/coastal features
  - boundary currents
  - upwelling zones
  - reefs, canyons, marine parks
  - population and development hubs

9. IMOS, delivered by Institutions operating ten National Facilities

- Argo Floats
- Ships of Opportunity
- Deepwater Moorings
- Ocean Gliders
- Autonomous Underwater Vehicles
- National Mooring Network
- Ocean Radar
- Animal Tagging and Monitoring
- Wireless Sensor Networks
- Satellite Remote Sensing

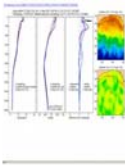
10-11. IMOS, making all data discoverable and accessible for free

- A key component of IMOS is the electronic Marine Information Infrastructure (eMII) Facility
  - responsible for creating and developing the information infrastructure
  - to make all data discoverable and accessible
  - via the IMOS Ocean Portal http://imos.aodn.org.au/webportal/



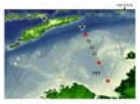
The IMOS Ocean Portal provides...

- information about deployments
- ISO-standard metadata
- access to the actual data
- plots, visualisations etc



12. IMOS in the Indian Ocean (a) 'Blue-water and Climate Node'

- Existing
  - Argo
  - Ships of Opportunity
  - Remote Sensing
- New Indonesian Through Flow mooring array
  - Shelf component in place
  - Deep component coming, in Timor Passage/Ombai Strait
  - plus US and Korean coverage of Makassar and Lombok Straits



13. IMOS in the Indian Ocean (b) 'Western Australian Regional Node'

- Focus on Leeuwin Current
- Existing
  - Ocean Gliders
  - Autonomous Underwater Vehicles
  - National Mooring Network
  - Ocean Radar
  - Animal Tagging and Monitoring
- New
  - Bonaparte Gulf shelf array in place (see previous)
  - Kimberley and Pilbara shelf arrays under consideration

14. Australia is also investing in a new 'blue water' research vessel

- from *RV Southern Surveyor*
- to *RV Investigator*
  - due mid-2012

Capacity issue	Current	Planned
Days at sea	up to 180	up to 300
Scientific berths	15	30-45
Endurance	26 days	55 days
Cruising speed	11 knots	12 knots
Range	~6,000 nm	>10,000 nm
Extent of operating area	50°S	Ice edge

15. In summary

- The Australia Government has begun to recognise the importance of sustained ocean observing for our country, as a 'marine nation'
- IMOS is now well-established as a national, collaborative, research infrastructure program
- It seeks to integrate
  - from open ocean, onto the continental shelf, and into the coast
  - across physics, chemistry, and biology
- And make all data discoverable and accessible for free
- We hope IMOS will provide a stronger basis for Australian collaboration with our regional and global partners
- And that we can sustain our effort over the coming decades

Annexure-4

Plenary Talk by Dr. Yukio Masumoto

IOP since IOP-6 in May 2009
and
vision for the future in the context of synergies with SIBER and the IRF

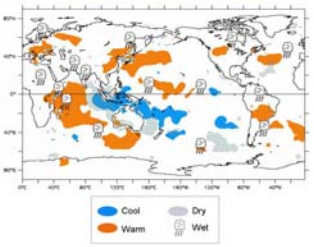
Co-chairs: Weidong Yu
Yukio Masumoto

Indian Ocean Science Drivers

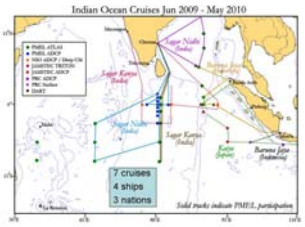
- Seasonal monsoons
- Severe weather events & cyclones
- Intraseasonal (30-60 day) variations, Madden Julian Oscillation
- Interannual variations: the Indian Ocean Dipole, Influence of ENSO
- Decadal variability and warming trends
- Ocean circulations & biogeochemistry

Indian Ocean is the most poorly sampled region of the tropics

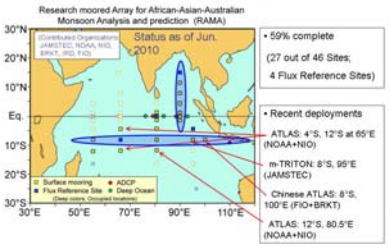
Impacts of poditive IOD during Austral Winter



RAMA Cruises: June 2009-May 2010



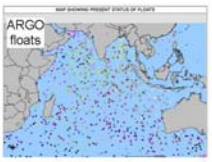
Mooring Array: Present Status



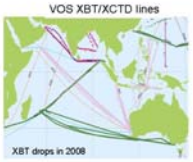
- 59% complete
(27 out of 46 Sites;
4 Flux Reference Sites)

- Recent deployments
ATLAS: 4°S, 12°S at 65°E (NOAA+NIO)
m-TRITON: 8°S, 95°E (JAMSTEC)
Chinese ATLAS: 8°S, 100°E (FIO+BRKT)
ATLAS: 12°S, 80.5°E (NOAA+NIO)

ARGO and VOS XBT



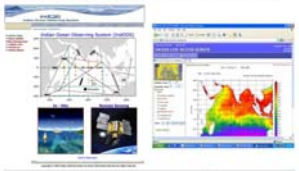
• 680 profilers in the Indian Ocean sector. (as of June 2010)



• Mostly well maintained. Some lines are not well covered (particularly, IX07 and IX08).

IndOOS Data Portal Site

✓ http://www.incois.gov.in/Incois/iogoos/home_indoos.jsp



✓ IndOOS data portal site is maintained by INCOIS, under the cooperation with APDRC, IPRC
✓ All the available data for IndOOS are listed with links to sources

Sciences using IndOOS Data

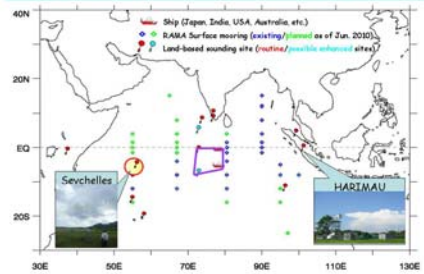
✓ New data obtained by IndOOS has already helped to improve our understanding of various phenomena of climate importance, such as;

i) the ocean dynamics associated with Indian Ocean Dipole,
ii) dynamics of the equatorial currents at intra-seasonal, semi-annual and annual time scales,
iii) upper ocean response (SST and mixed layer depth) to MJO and cyclone forcing and its potential feedbacks, and
iv) air-sea interactions and dynamics of monsoon variability

✓ More detailed information, and the full list of publications can be obtained at the IndOOS bibliography site at http://www.clivar.org/organization/indian/indOOS/biblio.php.

Coordination of process studies

CINDY is a multi-national field and modeling study of the oceanic and atmospheric processes responsible for the initiation of the intraseasonal Madden-Julian Oscillation (MJO)

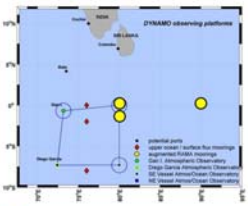


CINDY/DYNAMO

DYNAMO: the U.S. contribution to CINDY

Field phase scheduled for late 2011-early 2012

RAMA provides broad scale/long term context and platforms for enhanced measurements of ocean turbulence



○ RAMA moorings (augmented with ocean turbulence and other sensors)

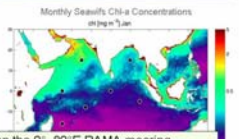
*Cooperative Indian Ocean experiment on intraseasonal variability *Dynamics of the MJO

Planned Biogeochemical Measurements:

A SIBER-RAMA Initiative

Objectives:

- Provide data for defining biogeochemical variability in key regions of the Indian Ocean and for understanding the physical, biological and chemical processes that govern it



(1) A fluorometer is added on the 0°, 80°E RAMA mooring

(2) A proposal to NASA was submitted to fund bio-optical sensors on RAMA moorings at 15°N, 90°E; 0°, 80°E; and 8°S, 67°E for three years beginning in 2011

(3) PMEL, JAMSTEC, and FIO are planning to attach CO2 sensors to some RAMA buoys

IndOOS Resources Forum (IRF)

- IndOOS has been implemented using bilateral corporations.
- IndOOS is being enhanced to include chemical and biological measurements
- Resources management has been an issue to implement/sustain the observing system.

- Establishment of the IRF under IOGOOS and its ToR were agreed at IOGOOS-6 (Hyderabad, 2008).
- A business plan of IndOOS Resources Forum (IRF) was also adopted by IOGOOS.
- The first IRF meeting will be held in Perth in July 16, 2010.

IRF is a critical activity to secure the ship-time and other resources for IndOOS.

Summary

- Many activities associated with IndOOS are in progress
- Strong linkage among IOGOOS, SIBER, IOP, and IRF is a key for full implementation of IndOOS

Annexure-5

Plenary Talk by Dr. Raleigh Hood

What is SIBER all about?

SIBER: Sustained Indian Ocean Biogeochemistry and Ecosystem Research

Indian Ocean Integrated Observing System

- SIBER initially emerged as a result of the potential opportunity to leverage the CLIVAR/GOOS Indian Ocean mooring array (RAMA/IndOOS) and associated measurements and cruises.
- SIBER has expanded to include the entire basin and all Indian Ocean observing components.

The IndOOS integrated observing system, with basin-scale observations by moorings, Argo floats, XBT lines, surface-drifters and tide-gauges; as well as boundary arrays to observe boundary currents off Africa (WBC), in the Arabian Sea (ASEA) and Bay of Bengal (BOB), the Indonesian throughflow (ITF), off Australia (EBC) and deep equatorial currents. RAMA: Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction.

SIBER Conference

Goa October 3-6, 2006
Initiated with funding from US NSF and India CSIR

Workshop Accomplishments:

- More than 200 registered participants from many nations.
- 44 invited speakers, > 50 poster presentations.
- Reviewed the state of our knowledge of the biogeochemical and ecological dynamics of the IO and identified prominent gaps.
- Provided the foundation for developing a new program in the Indian Ocean.
- Articles published in IMBER, *Eos* and an AGU monograph.

SIBER Writing Workshop

Goa November 27-30, 2007

Workshop Accomplishments:

- ~ 30 participants and 29 synthesis/overview presentations.
- Synthesized information presented at the 2006 SIBER conference.
- Considered related work, information and programs.
- Developed the six major research themes of the SIBER Science Plan.
- Developed the implementation components of the SIBER Science Plan.

SIBER/IOGOOS/IOP/IRF Symposium

Perth July 12-16, 2010

Symposium Participants and Goals:

- Joint meeting with CLIVAR's Indian Ocean Panel (IOP), Indian Ocean GOOS (IOGOOS) and the Indian Ocean Resources Forum (IRF).
- First SIBER Scientific Steering Committee Meeting and official launch of the SIBER Program.
- We hope that this will also be the official launch India's National SIBER Program.

SIBER Science Plan and Implementation Strategy:

The long term goal of SIBER is to improve our understanding of the role of the Indian Ocean in global biogeochemical cycles and the interaction between these cycles and marine ecosystem dynamics.

This understanding will be required in order to:

- Predict the impacts of climate change, eutrophication and harvesting on the global oceans and the Earth System.
- It is fundamental to policy makers in the development of management strategies for the Indian Ocean.

What is SIBER all about?

SIBER: Sustained Indian Ocean Biogeochemistry and Ecosystem Research

- It is a new, basin-wide program in the Indian Ocean focused on biogeochemical and ecological research, with existing and planned observing systems and expeditions providing the observational backbone.
- It is also an opportunity to promote interdisciplinary, international collaboration and research in the Indian Ocean.
- It is time. The last major program was JGOFS over 10 years ago.

India National SIBER Program Workshop

Goa April 13-14, 2009

Workshop Accomplishments:

- Sponsored by India's Ministry of Earth Sciences (MoES).
- Strong national participation.
- SIBER research proposals developed and presented.
- Considered outline and structure of an India National SIBER Program.

SIBER Science Plan and Implementation Strategy:

Final draft completed, reviewed and approved under IMBER and IOGOOS. The major components:

- Executive summary
- Introduction to the Indian Ocean
- Science Plan and Core Questions
- Implementation Strategy
- Integration
- Conclusions and Legacy

Science Plan Editors:

- Raleigh Hood (USA, chair)
- Wajih Naqvi (India, co-chair)
- Jerry Wiggert (USA)
- Michael Landry (USA)
- Timothy Rixen (Germany)
- Lynnath Beckley (Australia)
- Catherine Goyet (France)
- Greg Cowie (UK)

SIBER Science Plan and Implementation Strategy:

To address this long-term goal SIBER has structured its research around six major scientific themes.

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: Dynamic variability of the equatorial zone, southern tropics and Indonesian Throughflow and their impacts on ecological processes and biogeochemical cycling (*How do the 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 Science Plan and Implementation Strategy:

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?*)

SIBER Science Plan and Implementation Strategy:

The SIBER Science Plan is ambitious and very broad

- It encompasses biogeochemical research from the continental margins to the deep sea and trophic levels ranging from phytoplankton to top predators including fish and humans.
- It should be emphasized that this plan is intended to provide a set of options (i.e., scientific themes) for different countries to consider as potential research foci in the Indian Ocean.
- This approach is necessary in order to accommodate the broad (and often regional) interests of many countries that are interested in pursuing research in the Indian Ocean.

SIBER Science Plan and Implementation Strategy:

The Implementation Strategy has three major areas of science activity:

1. Remote sensing Studies:

➢ The obvious starting point for addressing the long-term goal of SIBER is through the use of remote sensing to better characterize the intense variability that is observed in the Indian Ocean.

➢ There is still a need for carrying out first-order descriptive science based on remote sensing.

➢ Interdisciplinary retrospective and process-oriented remote sensing studies should seek to better quantify both the physical (SST and SSH) and biological (ocean color) variability, understand the impact of physical forcing on biological processes, and also characterize longer-term change.

SIBER Science Plan and Implementation Strategy:

2. Modeling Studies:

➢ There are still substantial challenges associated with modeling the highly dynamic regions in the Indian Ocean.

➢ Eddy-resolving models (e.g., 1/10th of a degree or less) are required in order to resolve the physical and biological variability in many Indian Ocean current systems and data assimilation techniques will need to be employed to optimize both physical and biological models.

➢ SIBER will encourage the use of existing eddy-resolving models in the Indian Ocean (e.g. Australia's BLUElink model) and also the development of new data-assimilating models.

➢ Applying coupled physical-biological models to study ecosystem dynamics and higher trophic levels is still a significant research challenge.

➢ SIBER will encourage the development and use of end-to-end food web modeling approaches, and especially new model structures that are adaptive and/or generate emergent behavior.

SIBER Science Plan and Implementation Strategy:

3. In situ observations and potential for leveraging existing infrastructure:

➢ Initial emphasis in SIBER will be placed upon data mining.

➢ First-order, descriptive in situ observational studies still need to be undertaken in the Indian Ocean to characterize phytoplankton, zooplankton and nekton assemblages and seasonality of the populations.

➢ Existing long-term monitoring stations need to be maintained, e.g., in the Arabian Sea and elsewhere.

➢ Targeted process studies will be motivated at specific sites and times that focus on addressing the core SIBER science questions.

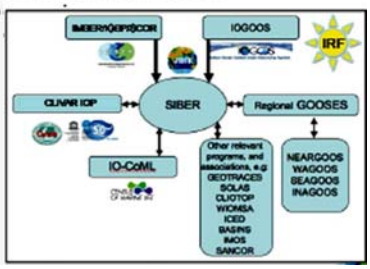
➢ A program of systematic benthic process studies is needed.

➢ *Studies motivated as a part of SIBER must target and build upon existing monitoring and research infrastructure (e.g., IndOOS, IMOS, etc.).*

Programmatic Synergies:

➢ IMBER and IOGOOS provide logical international programmatic homes for SIBER
➢ SIBER is now a major regional program under IMBER
➢ SIBER is now the biogeochemical and ecosystem research component of IOGOOS
➢ These linkages will also promote links between IMBER and IOGOOS
➢ SIBER (and other programs) will need help from the IRF to succeed

SIBER will endeavor to coordinate with and leverage:
- ➢ CLIVAR IOP
- ➢ Regional GOOSES
  - NEARGOOS
  - WAGOOS
  - SEAGOOS
  - INAGOOS
- ➢ IRF
- ➢ IO-CoML
- ➢ Other relevant programs and associations:
  - GEOTRACES
  - SOLAS
  - CLIOTOP
  - WIOMSA
  - ICED
  - BASINS
  - IMOS
  - SAHCOR



Legacy:

➢ The coordination and integration of Indian Ocean biogeochemical and ecosystem research through SIBER will advance our knowledge of this under-sampled basin and provide a major contribution to the understanding of how regional and global change may impact biogeochemical cycles and ecosystem function, not only in the Indian Ocean, but in the Earth System, creating a lasting legacy on which future research can build.

➢ The scientific findings will inform scientists in the international community and provide a focus for future research on important regional, basin-wide and global issues.

➢ These findings will also provide policy makers with the sound scientific basis upon which to make decisions on how to manage Indian Ocean ecosystems.

➢ SIBER will leverage and strengthen GOOS and IMBER by promoting coordinated international, multidisciplinary research in developed countries, and also human resources and infrastructure development in many developing Indian Ocean rim countries.

Relevance of SIBER to Australia:

➢ SIBER can help to extend WAIMOS/WAGOOS into open ocean waters.

➢ SIBER can help promote interaction and exchange between Australia other Indian Ocean rim nations.

➢ *SIBER can help provide a larger scale scientific context for biogeochemical and ecosystem studies that are being undertaken in Australia's coastal waters.*

➢ *This will allow Western Australia (and for that matter, Australia nationally) to better understand and predict its own oceanographic and coupled climate processes, as they affect marine biogeochemical cycles and ecosystem dynamics and, ultimately, society.*

Planned Biogeochemical Sensor Deployments on RAMA

(A SIBER-RAMA Initiative)

Objectives:

➢ Provide data for defining biogeochemical variability in key regions of the Indian Ocean for understanding the physical, biological and chemical processes that govern it.

Key Measurements: CO_2, Fluorescence, Particle Backscatter, O_2

Target Locations: Flux reference sites in the Arabian Sea, Bay of Bengal, Equator, Seychelles-Chagos Thermocline Ridge

Annexure-6

Plenary Talk by Dr. Gary Meyers

Indian Ocean Observing System (IndOOS) Resources Forum

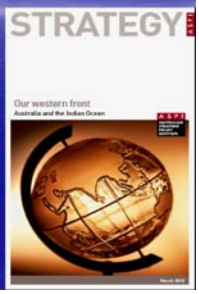
Gary Meyers
Convenor

Indian Ocean passion since 1983

Australia and the Indian Ocean

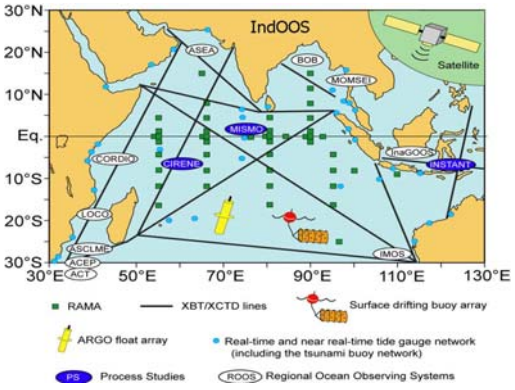
"That the Indian Ocean region is of critical strategic importance to Australia is substantially underappreciated..."

Steven Smith MP Minister for Foreign Affairs
Perth, 31 March 2010



History leading to the IRF (1)

- SOCIO 2000 Perth
- 2004 CLIVAR-GOOS Ind Ocean Panel
- 2006 IndOOS Implementation Plan



History leading to the IRF (2)

- IRF developed and approved at 5th and 6th Annual Meetings of IOGOOS (2007 & 2008)
- Facilitation through the UNESCO IOC Perth Office
- First meeting Thur 15 July
  - Open plenary 0900-1030
  - By invitation 1100-1700

Objective of the IRF—a step toward sustained observing

- Provide a multi-institutional forum for the coordination of resources for implementation of IndOOS
- Facilitate the identification and alignment of resources (eg ocean observing infrastructure, scientific capacity, vessel support) 2-3 years in advance
- Carry out the IOP and SIBER implementation plans

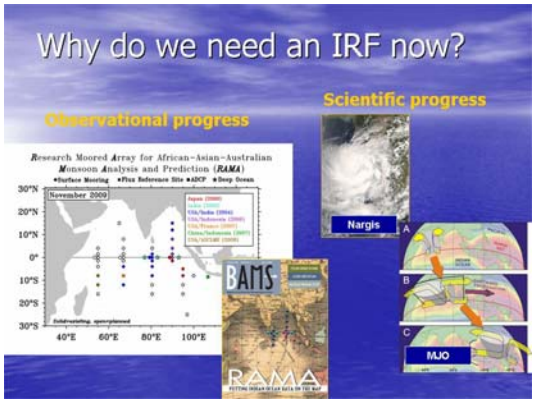
Members

Indian Ocean region

- India: Dr Shailesh Nayak, Secretary, Ministry of Earth Sciences, India
- Australia: Mr. Tim Moltmann, Director, Integrated Marine Observing System
- Indonesia: Dr. Ridwan Djamaluddin, Director, Environmental Services, BPPT
- Mauritius: Dr Mitrasen Bhikajee, Director, Mauritius Oceanography Institute
- E.Africa: Dr. David Vousden, Director, Agulhas and Somali Current LME
- South Africa: Mr Mark Majodina, Manager of International Relations, SAWS

Outside the Indian Ocean Region

- Japan: Dr. Shiro Imawaki, Executive Director, JAMSTEC
- USA: Dr. Chester Koblinsky, Director, Climate Program Office, NOAA
- China: Mr. Lin Shanqing, Director-General, Office of Ocean Forecast; Mr Chen Zhi, Director, Office of Ocean Observation, SOA
- France: Dr. Patrick Monfrey, Directeur-adjoint, l'Institut National des Sciences de l'Univers
- UNESCO: Dr. Wendy Watson-Wright, Assistant Director General UNESCO; Executive Secretary IOC

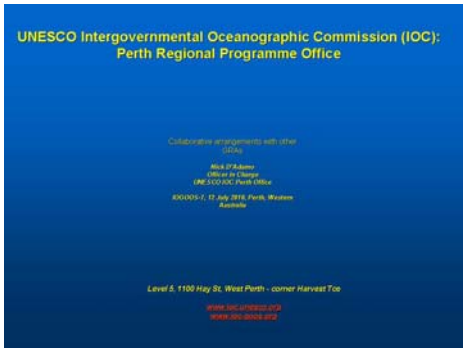


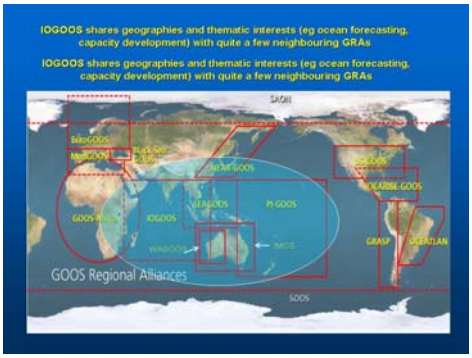
Key points of discussion

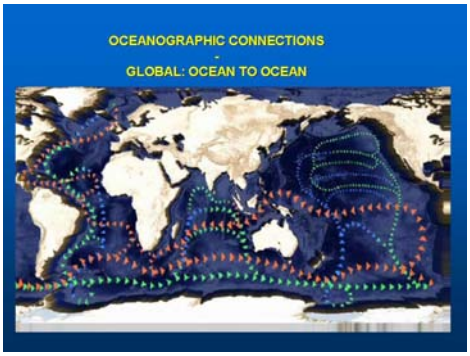
- Networking
- Overview of present day contributions
- Identify needs of IOP and SIBER and calibrate the needs against the societal benefit of the science
- Approaches to urgent, present day needs
  - Access to shiptime to maintain and implement the basin mooring array (RAMA)
  - Enhance RAMA with biogeochemical sensors
  - Other needs may arise at IOP &SIBER meetings

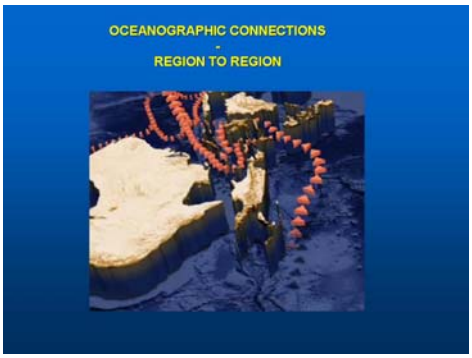
Annexure-7

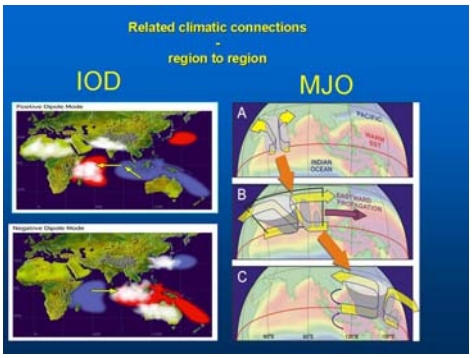
Remarks by Dr. Nick D' Adamo

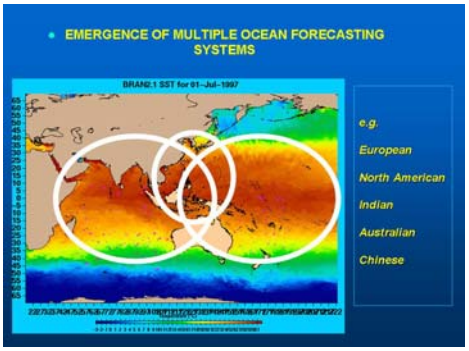


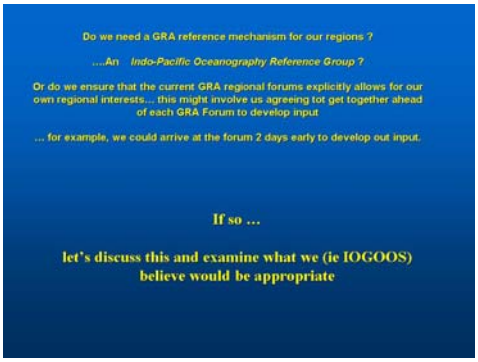






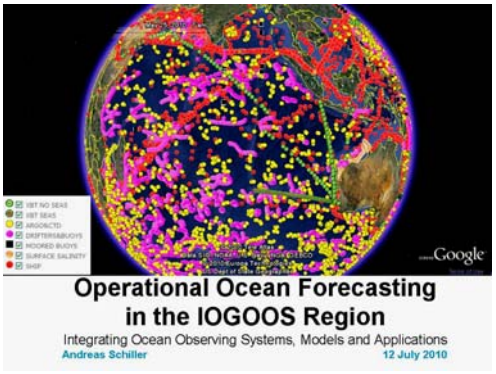


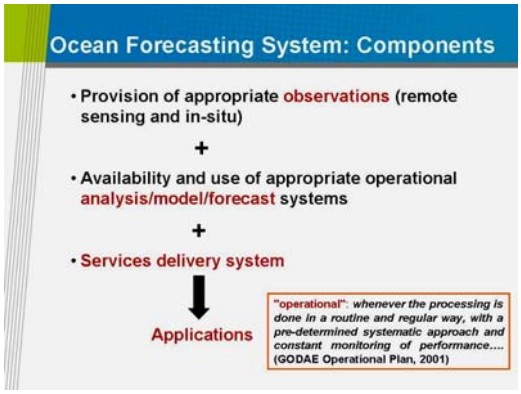


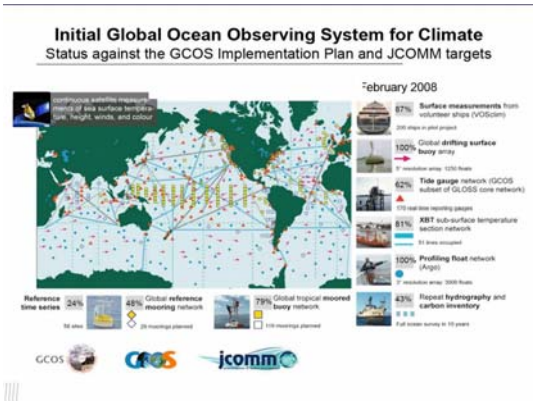


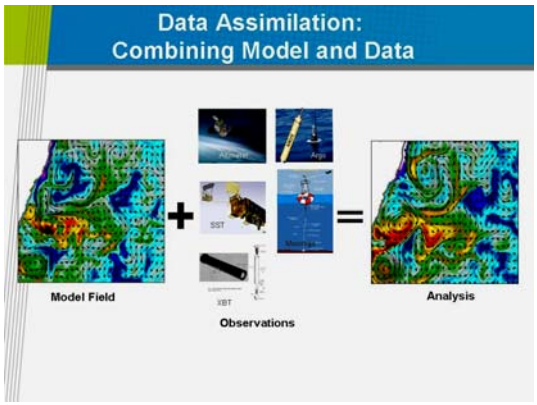
Annexure-8

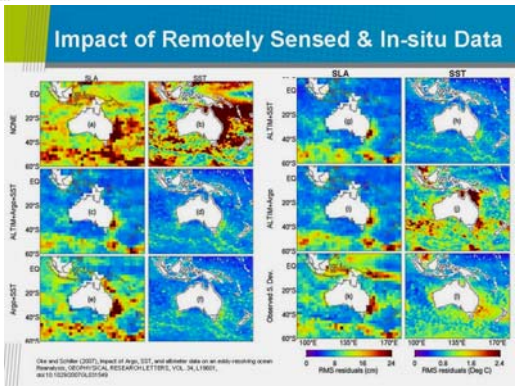
Science Talk by Dr. Andreas Schiller

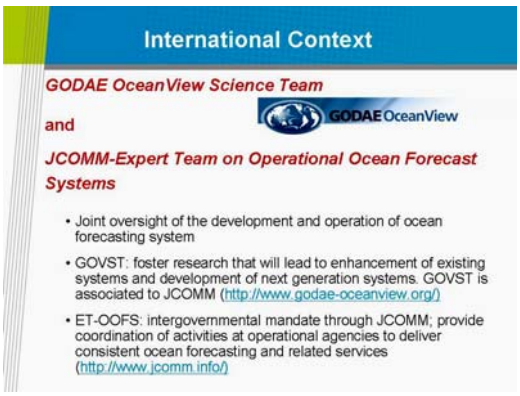












Indian Ocean Forecast System (INDOFOS)

Development of Indian Forecasting Capability

INCOIS - experimental operational forecasts:

- Initial focus on North Indian Ocean with interannual run with daily forcing (NCEP, ECMWF, NCMRWF) using MOM4, ROMS, HYCOM and CUPOM.
- Operational system: no assimilation of observations yet; using forecasted atmospheric forcing (http://www.incois.gov.in/Incois/indofos_main.jsp).
- Collaboration with NCEP about assimilation of Argo floats data and SST (Reynolds)
- Long-term plan: use MOM for global domain with (¼)° resolution and ROMS in the North Indian Ocean (with multiple nesting to resolve coastal currents); forcing from NCMRWF

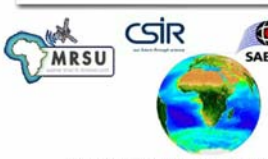
➔ Details: See presentation by Dr Ravichandran

Contents

- Introduction:
  - What is Ocean Forecasting/Operational Oceanography?
  - International Context
- Tools, Products and Applications:
  - India/INDOFOS
  - **South Africa/OceanSAfrica**
  - Australia/BLUElink
- Summary

OceanSAfrica Introduction and Overview

Designing, planning and implementing an Operational Oceanography System for Southern Africa



Bjorn Backeberg, Stewart Bernard and Jennifer Veitch

http://sea.uct.ac.za/2010/05/operational-oceanography-initiative/

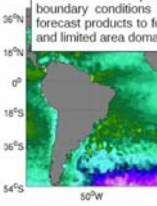
SimOcean: modelling pillar of OceanSAfrica

Phase 1: implementation
2 year horizon

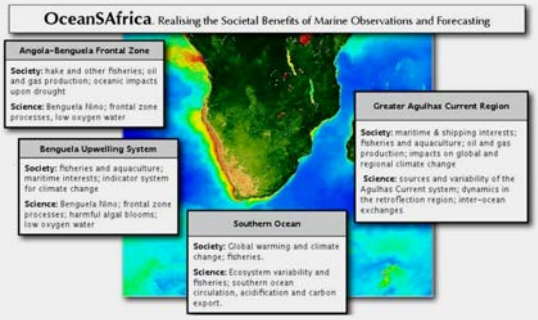
Downscaling approach: use already available atmospheric forcing and boundary conditions from existing global forecast products to force nested, regional and limited area domains.

Phase 2: operational system improvements
5 year horizon

System development & research:
- data assimilation
- coupling:
  - atmospheric
  - bio-geochemical
  - wave
- development of additional high resolution limited area domains



OceanSAfrica. Realising the Societal Benefits of Marine Observations and Forecasting



Contents

- Introduction:
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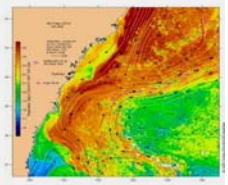
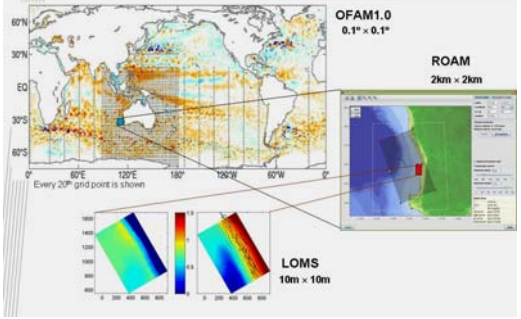
  - India/INDOFOS
  - South Africa/OceanSAfrica
  - **Australia/BLUElink**
- Summary

What is Bluelink?

- **Goal: An ocean forecasting system to meet the needs of the entire Australian marine sector for timely and detailed information on the (bio-) physical state of the ocean**
- **A partnership: RAN, BoM and CSIRO**
- **A sustained effort:**
  2002-2006, 2006-2010, 2010-2013
  ~$5M/yr
- **Sub-systems:**
  - **Assembly and processing of observations**
  - **Global ocean model**
  - **Limited-area model**
  - **Relocatable model**
  - **Littoral-zone model**
  - **Product delivery**



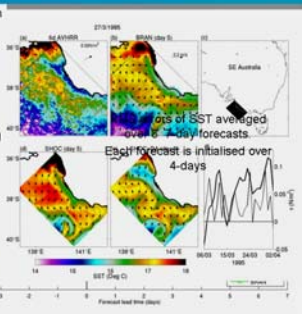
Global and Nested Models



Coastal Ocean Data Assimilation

Example of an 8-week application to the Bonney coast during a strong wind-driven upwelling period (March 1995):

- Assimilating AVHRR SST
- The Obs show very strong upwelling
- BRAN shows a weak upwelling – that is recreated by the nested model
- Assimilation into the nested model improves the simulation, yielding positive forecast skill



National Services: Bureau of Meteorology

Products and Services

Graphical products

Online graphical public service

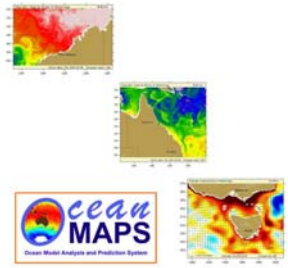
www.bom.gov.au/oceanography/forecasts

Data services

Registered user research server - OPeNDAP

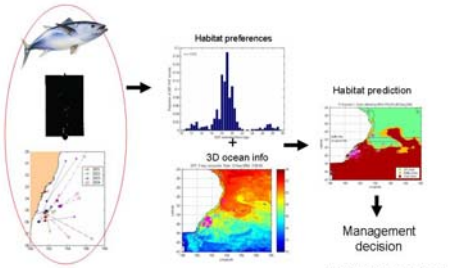
OceanMAPS ocean forecasts

RAMSSA/GAMSSA SST analyses



Dynamic Spatial Strategies

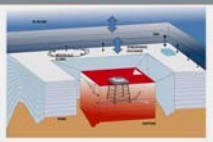
Southern Bluefin Tuna Management

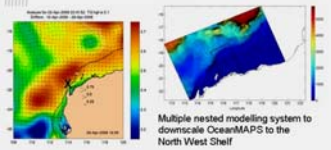


Hobday and Hartmann (2006)

Applications - Industry

Engineering design of underwater pipelines, Offshore construction, Management of oil and gas operations

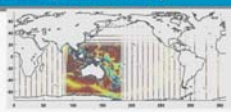




Multiple nested modelling system to downscale OceanMAPS to the North West Shelf

Montara Oil Spill off WA – Aug to Dec 2009

Outlook: BLUElink 3 (2010-2013)



OFAM1&2: Eddy-resolving around Australia (1/10)°

- Daily forecasts
- Improved DA
- New: nearly global eddy-resolving ocean model
- New: capability for formal analysis error estimates
- Continued: Regional coupled ocean-wave-atmosphere models with DA (e.g. cyclone forecasting)
- New: evaluate biogeochemical forecasting capability in global system (reanalysis mode)
- Continued: Design 3-d visualisation package
- Continued: Development of littoral-zone prediction system, inc. waves, currents and geomorphology

Summary

- Operational Oceanography has become of age, i.e. multi-scale, increasingly multidisciplinary (physics, bgc, …)
- Observing systems (GOOS) and forecasting systems (e.g. Bluelink) have a lot to offer each other
- Neither have achieved their end-goals yet but
  - both have already radically changed the oceanographic landscape
  - Bluelink3 (2010-2013): make fuller use of Australia's GOOS
- Lessons learnt: researchers and end users want multitude of multi-scale products (e.g. gridded, point-wise) as well as more-precise, location-specific data sets (➔ error estimates)

Annexure-9

Science Talk by Dr. Nicolas Hoepffner

Applications of Satellite Data to Marine Ecosystem Management

Nicolas Hoepffner
European Commission – Joint Research Centre, Ispra, Italy

Shubha Sathyendranath, and Trevor Platt
Plymouth Marine Laboratory, Plymouth, UK

Chlorophyll Global Integrated Network GEO task EC-09-01

"An international network for promoting ocean colour and related satellite and in water observations to assess the state of marine coastal and inland water ecosystems for the benefit of society."

www.neodaas.ac.uk
emis.jrc.ec.europa.eu
cearac.nowpap.org
http://home.antares.ws/
www.chlorogin-africa.org.za
amis.jrc.ec.europa.eu
www.incois.gov.in/Incois/pfzarchiveimages1.html
www.chlorogin.org

ChloroGIN Objectives

- Provide time series of ecosystem indicators for management of fisheries, aquaculture, coastal zones & inland water bodies
- Support satellite observations with in situ measurements for ground-truthing to local conditions, & characterizing sub-surface water properties for assessing pollution, ecological status & potential for human use
- Develop & supply value-added products needed for management by local authorities, regional and national governments
- Communicate ChloroGIN products of ecosystem state widely to potential users in society and in policy-making bodies
- Capacity building to promote the analysis and applications of satellite data in coastal waters and regional seas

ChloroGIN – Indian Ocean

http://www.incois.gov.in/Incois/pfzarchiveimages1.html

- Automatic data processing and distribution of daily, weekly, monthly OC products to IOGOOS member institutions
- Capacity building and technical workshops on satellite data processing and applications
- SATCORE network: 8 time-series stations off E and W coast of India with monthly surveys for cal/val activities and algorithm development

Chl_a

Sampling frequency	Monthly
Sampling parameters	Chlorophyll, SST, TSM, CDOM, DO & Nutrients
Instruments	Hyperspectral Radiometer, Spectrophotometer, Fluorometer

JRC - Ocean Colour Training Course Series

" Methods and Applications of Ocean Colour Remote Sensing in Costal and Regional Seas "

- Ispra (Italy) 3-14 Oct. 2005 – *Central and Eastern Europe Countries*
- Mombasa (Kenya) 24 Sept.-5 Oct. 2007 – *Africa and Western Indian Ocean Islands*
- Zanzibar (Tanzania) 12 – 23 Oct. 2009 – *Africa and Western Indian Ocean Islands*
- Mauritius Nov. 2011 in prep.

SAFARI Initiative - *Societal Applications in Fisheries and Aquaculture using Remotely-sensed Imagery*

- Initiated in 2007 from GEO request to assimilate EO data into fisheries research and ecosystem-based fisheries management
- GEO Task AG-06-02
- Three years funding from Canadian Space Agency

Objectives:

- Facilitate applications of rapidly evolving satellite technology to fisheries management questions
- International forum for coordination and exchange of views on use of EO data in fisheries oceanography
- Set-up a vehicle for transfer of knowledge from the research sector to the operational sector
- Stimulate capacity building and new research in this area

SAFARI activities

- International Workshop, Halifax, March 2008
- SAFARI Brochure, October 2008
- Monograph in IOCCG series, October 2009
- Special session ASLO, Nice (France), January 2009
- International Symposium, Kochi (India), February 2010

Context: Stewardship of the Oceans

- Global consensus (UN Declaration): Management should have ecosystem basis, system integrity should be maintained.
- Preserve ecosystem attributes such as health, vigour, resilience, but these are difficult to quantify.
- Instead, develop suite of Ecological Indicators:

" Objective metrics for the pelagic ecosystem that can be applied serially, in operational mode, to detect changes in ecosystem characteristics " (Platt et al. 2009)

Remote Sensing for Operational Metrics

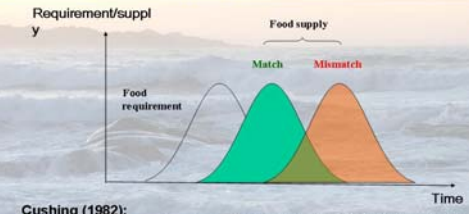
- Meets requirements of speed, resolution, repeat frequency and cost-effectiveness
- Autotrophic biomass important, well understood and widely accepted ecosystem property
- Primary production fields can also be generated
- SST and chlorophyll obtainable at same resolution
- Can construct time series: seasonal dynamics can be quantified objectively in standard units
- Allows inter-annual comparisons

Phytoplankton Bloom Dynamics

Any or all of these indices may vary between years (at any or all of the pixels in the region of interest)

Do these ecosystem variations have any significance for the ecosystem at higher trophic level ?

Match – Mismatch Hypothesis (Cushing 1969)



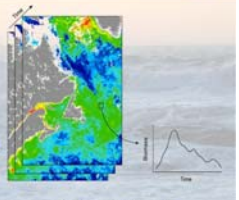
Cushing (1982):

1. If matched, recruitment would be high within the limits of variation of the primary production.

1. If mismatched, recruitment will be low- more so if primary production is low, but less so if it is high.

N.E Atlantic Haddock Fishery (Platt et al. *Nature* 2003)

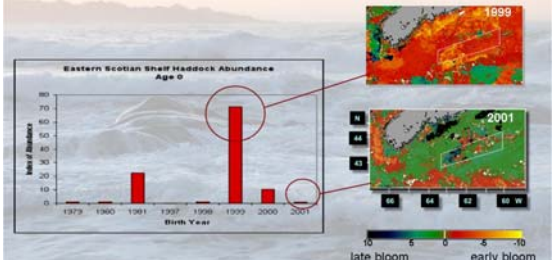
- Characterise spring bloom in each year by objective, quantitative criteria, preserving all spatial structure
- Compare these ecosystem indices with larval survival in corresponding years



- Test whether significant proportion of variance in larval abundance (survival) can be accounted for by variations in ecosystem indices

N.E Atlantic Haddock Fishery (Platt et al. *Nature* 2003)

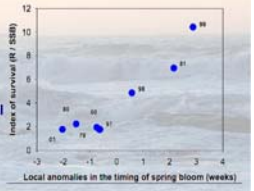
Anomalies in bloom timing



N.E Atlantic Haddock Fishery (Platt et al. *Nature* 2003)

89% of the variance in the survival of haddock larvae can be accounted for by the timing of the spring bloom.

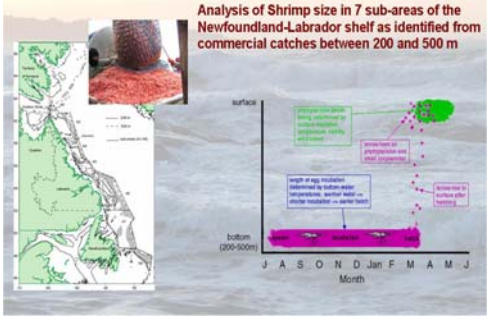
In a 30-year time series on haddock recruitment, the only two exceptional year-classes coincided with spring blooms that were unusually early.



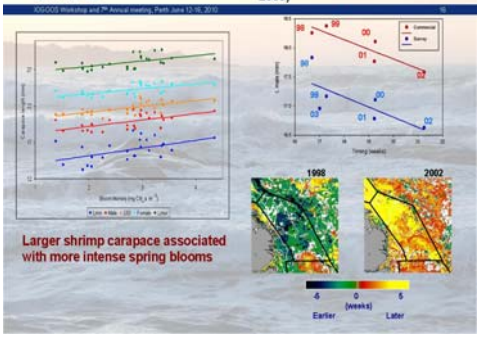
This finding could not have been made, other than by remote sensing.

N. Atlantic Shrimp (Koeller et al 2006, 2009)

Analysis of Shrimp size in 7 sub-areas of the Newfoundland-Labrador shelf as identified from commercial catches between 200 and 500 m



N. Atlantic Shrimp (Koeller et al 2006, 2009)

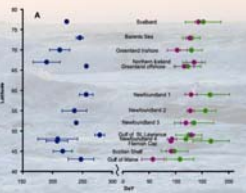


Larger shrimp carapace associated with more intense spring blooms

N. Atlantic Shrimp (Koeller et al 2006, 2009)

Strong links between shrimp growth and food availability, as indexed by either the intensity or the timing of the spring bloom

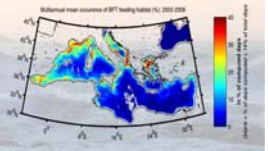
Analysis on North Atlantic shrimp populations showed a tight coupling between eggs hatching and bloom timing



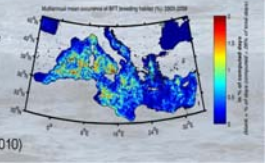
Long time series of satellite observations are essential to analyse population dynamics at regional scales

Bluefin Tuna Habitat Monitoring in the Mediterranean Sea

Feeding habitats
(simultaneous oceanic fronts of temperature [SST] and chlorophyll [CHL-a])
- SST ca. 20-22°C
- Chla ± 0.3 – 0.5 mg.m^{-3}



Spawning habitat (temperature increase over 30 days and Chl < 0.1 to 0.15 mg.m^{-3}).



(J.-N Druon, Marine Policy 2010)

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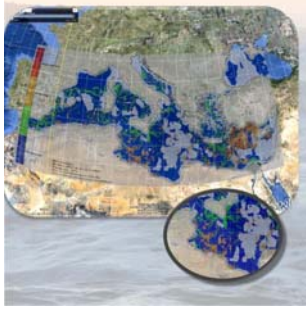
Bluefin Tuna Habitat Monitoring

IOGOOS Workshop and 7th Annual meeting, Perth June 12-16, 2010 19



Operational 3-day product on Tuna feeding and spawning habitats

EU Community Fisheries Control Agency (Vigo, Spain)

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IOGOOS Workshop and 7th Annual meeting, Perth June 12-16, 2010 20

Potential improvements for the fishery management – Guided /responsible Fisheries -

1. An efficient control is the most important element to reduce illegal fishing.
   The restriction of fishing grounds to some feeding areas and the monitoring of spawning areas would lead to a significant increase of the control efficiency at sea

2. **Fishermen could save up to 50% of the variable costs if guided in feeding areas (saving fuel, man-days at sea),**
   The quotas would be filled each year while the costs would be reduced.

3. **Sustainable fisheries and the recovery of bluefin tuna stocks *are only possible by protecting the breeding areas.***

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Concluding Remarks

IOGOOS Workshop and 7th Annual meeting, Perth June 12-16, 2010 21

- **EO can support marine ecosystems management in many ways:**
  - Primary ecological indicators *vs* physiological processes of higher trophic organisms
  - Oceanic features *vs* spatial and temporal distributions of fish populations
  - Global assessment of stocks, long-term changes, hazards monitoring and early warning services, protection of species at risk, coastal and marine governance……
- **Globally, EO could be exploited in operational fisheries more than it is at present, both in respect to number of users and user objectives.**
- **Develop capacity-building and outreach effort, and collaboration between scientists and economists, the fishing community and other stake-holders.**

Annexure-10

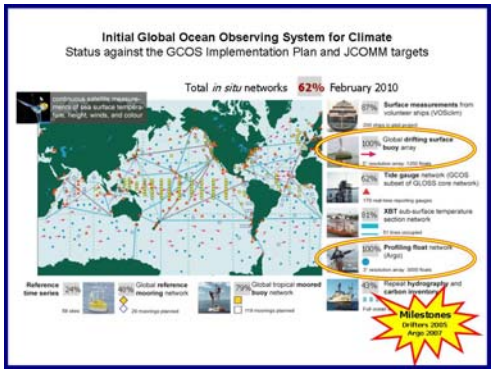
Science Talk by Dr. Sidney Thurston

The First DBCP In-Region Western Indian Ocean Capacity Building Workshop

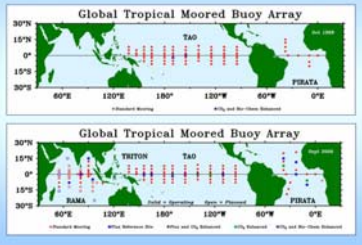
Indian Ocean GOOS (IOGOOS-7)
Perth, Australia
12 July 2010

Dr. Sidney Thurston
NOAA Climate Program Office

1



Global and Indian Ocean Buoys 1999 → 2009



3

NOAA's Goals For the Indian Ocean Region

- Working Closely With Regional Colleagues, NOAA Seeks to Build & Sustain Infrastructure to Provide Services to Benefit Society
  - » Observations
  - » Forecasts
  - » Analysis
  - » Capacity Building

4

International Cooperation For IndOOS and RAMA

Formal Bilateral Agreements Between NOAA and Agencies in:

- India - signed in 2008
- Japan - signed in 2008
- Indonesia - signed in 2009
- ASCLME (9 East African countries) - Planned in 2010

Agulhas Somali Large Marine Ecosystems (ASCLME)

- 2 NOAA ATLAS and 4 Argo floats deployed during ASCLME cruise on *R/V Fridtjof Nansen* - Seychelles to Mozambique 18-27 Nov 2008
- Second Cruise Scheduled This October

Workshop Goals

- Implementation and Operations Of Indian Ocean Data Buoy Networks and their Applications for Enhancing Regional Predictive Capability
- Begin to Build Capacity Within Regional Institutes to Apply New Indian Ocean Observing System (IndOOS) Data, such as from RAMA and others, for Enhanced Predictive Capability for the Region,
- Demonstrate the Crucial Role of Ocean Observations for Understanding and Predicting Regional Weather, Ocean and climate,
- Build In-Region Modelling Development Teams (MDT) and Observation Development Teams (ODT), including for the implementation of buoy programmes,
- Demonstrate the Societal and Economic Benefits of Delivering Enhanced Ocean Observing System Data for Better Informed Decisions,

7

Sponsors and Contributors

- WMO/IOC JCOMM Data Buoy Cooperation Panel (DBCP)
- South African Weather Service (SAWS)
- Intergovernmental Oceanographic Commission (IOC)
- National Oceanic and Atmospheric Administration (NOAA), USA
- UNDP/GEF Agulhas-Somali Current Large Marine Ecosystems Project (ASCLME)
- Ministry of Earth Sciences (MoES), India
- Global Learning and Observations to Benefit the Environment (GLOBE)

8

Sixty One Participants Represented

- South Africa
- India
- Kenya
- Tanzania
- Sri Lanka
- Madagascar
- Mauritius
- Seychelles
- Uganda
- Ethiopia
- Pakistan
- Namibia
- United States

9

Some of The Presentations

- The Influence of Indian Ocean on East African Climate – The Need for Observation
- An Operational Ocean Prediction System for the Western North Atlantic: A Model to Develop similar Capacity for the South Western Indian Ocean
- African Monitoring of the Environment for Sustainable Development (AMSED)
- Regional Applications of the NCEP Coupled Forecast System (CFS)
- Ocean observing systems: Australia (IMOS) and Indian Ocean (IOGOOS).

10

Some of The Presentations

- National Perspective on Buoy Programme Implementation (Mauritius) – All Nations Made National Reports
- Developing An In-Situ (Real-Time) Regional Measurement System Around Southern Africa
- The SimOcean initiative A strategy for building ocean modelling capacity in South Africa
- Scientific Justification for Western Indian Ocean observing Network: Reports by Regional Experts

11

DBCP Capacity Building workshop for the Western Indian Ocean region

Cape town, South Africa, 13-23 April 2010

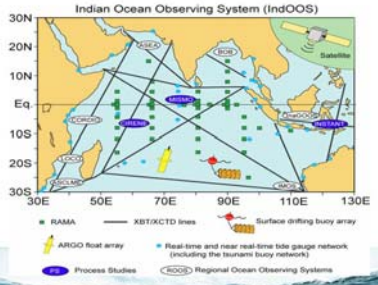
Scientific Justification for Western Indian Ocean observing Network

Reports by Regional Experts

Scientific drivers

- East Africa Low Level jet
- Convergence zone of the EACC and SC
- Wind derivatives over the upwelling region of the East African Coast
- MJOs
- Equatorial trapped Kelvin Waves and Rossby waves

Present situation



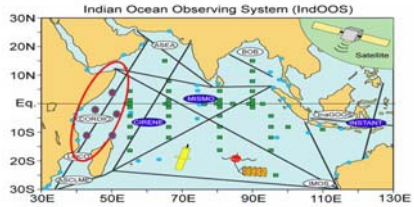
Scientific Justification

- Real-time Ocean observation to calibrate/validate both modeling and satellite
- Understand the evolution of surface pressure over the East African coast which have high forecasting potential for the WIO region
- Monitor ocean atmosphere fluxes and the Somali current "gyre" over the upwelling region of eastern African Coast

Scientific Justification (continued)

- Investigate the correlation between intra-seasonal dry and wet spells and the propagation of MJO oscillations
- Enhance the understanding of the Indian Ocean Dipole
- The need to improve coastal stations (tide gauge network) to study sea level variations, sea level rise, storm surges, Tsunamis and climate change

Proposed moored buoys



Related issues

Human Capacity Building

- Capacity in ocean modeling
- Capacity in ocean platform deployment, Data access and application, like wave and swell data
- Capacity to plot buoy data available in GTS due to lack of software to do that.

There is therefore a need to build the capacity of local scientists in the region in those areas

Next Steps Forward

- Work With IOGOOS & IOP To Further Coordinate the Regional Science With the Broader IndOOS Objectives, Explore Resourcing
- Convene the *Second Annual Western Indian Ocean Capacity Building Workshop Next Spring* to Advance Progress With Regional Institutes

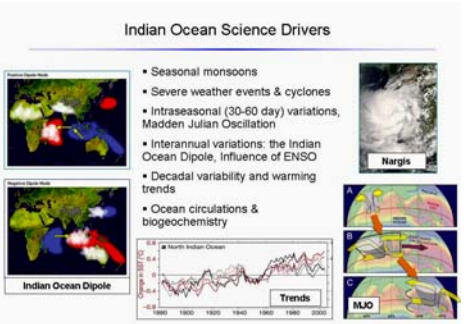
19

Science Talk by Dr. Yukio Masumoto

Indian Ocean Observation
- Present status and science highlights -

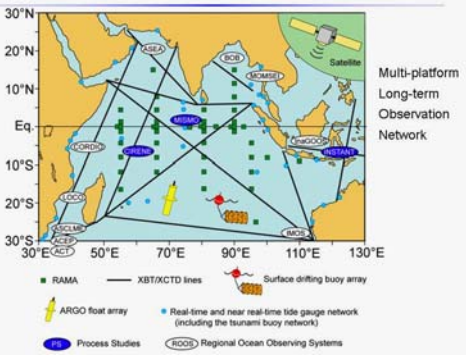
Co-chairs: Weidong Yu
Yukio Masumoto

Indian Ocean Science Drivers



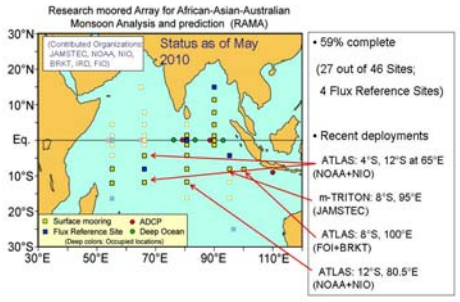
Indian Ocean is the most poorly sampled region of the tropics

Indian Ocean Observing System (IndOOS)



Multi-platform
Long-term
Observation
Network

Mooring Array: Present Status

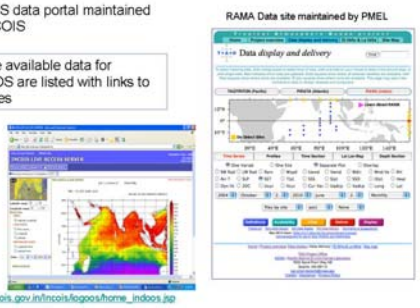


IndOOS Data Portal & RAMA Data sites

IndOOS data portal maintained by INCOIS

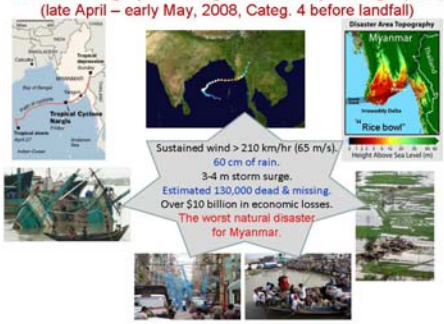
All the available data for IndOOS are listed with links to sources

RAMA Data site maintained by PMEL

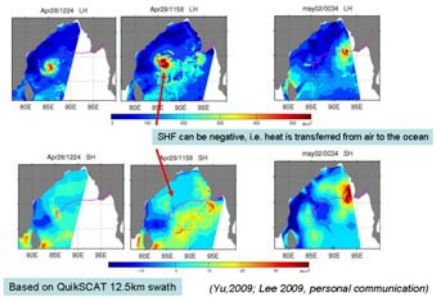


http://www.incois.gov.in/Incois/iogoos/home_indoos.jsp

The devastating Cyclone Nargis from the Bay of Bengal (BOB)
(late April – early May, 2008, Categ. 4 before landfall)

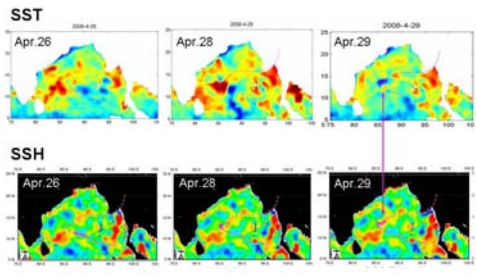


OAFlux estimation of Nargis latent and sensible heat fluxes



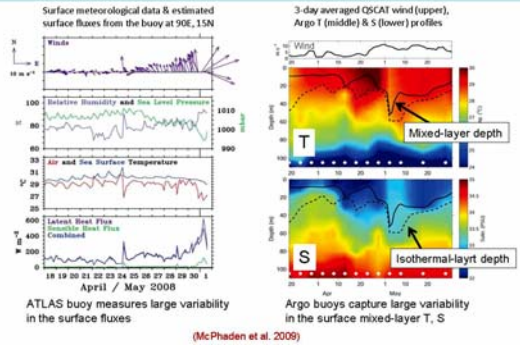
(Yu,2009; Lee 2009, personal communication)

Warm core ring signature in SST

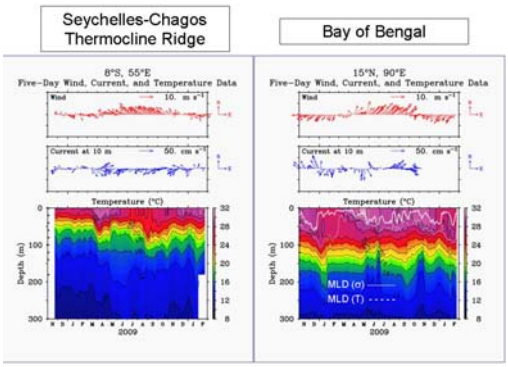


(Yu,2009; Lee 2009, personal communication)

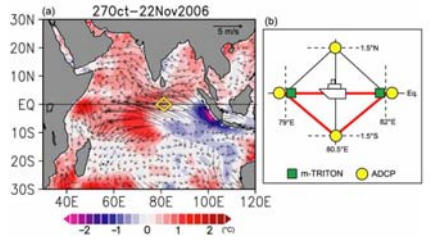
Variability associated with Cyclone Nargis



(McPhaden et al. 2009)

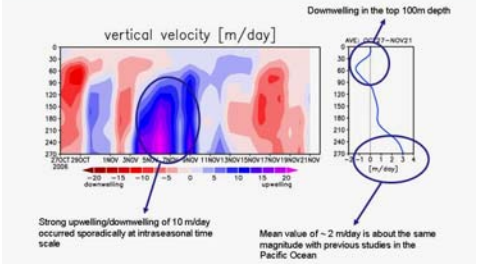


MISMO Observations and Large-scale Background Conditions

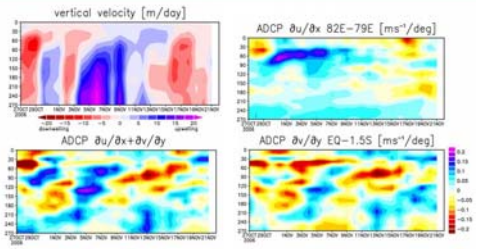


MISMO observations were conducted during the height of 2006 IOD event.

Vertical Profile of w

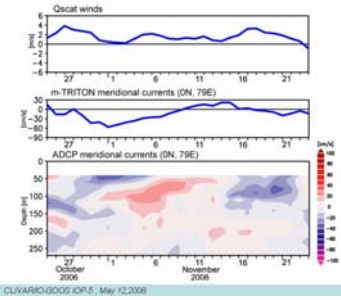


Causes of strong upwelling



• Large amplitude vertical motion is associated with the subsurface meridional current divergence at the intraseasonal time scale

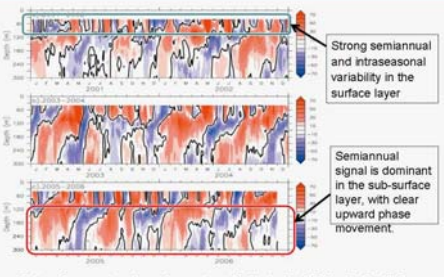
Zonal and Meridional Currents during MISMO



✓ Subsurface eastward flow centered at 80m depth, with surface westward flow, during relatively strong easterly wind period.

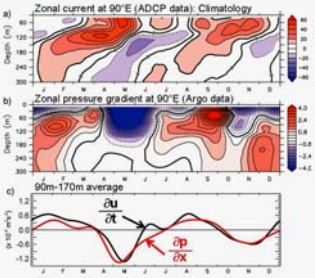
✓ Strong biweekly variability is observed between 40m and 150m depth.

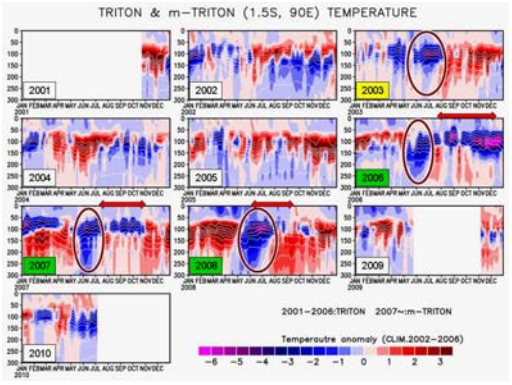
Observed Zonal Current at 0°N, 90°E

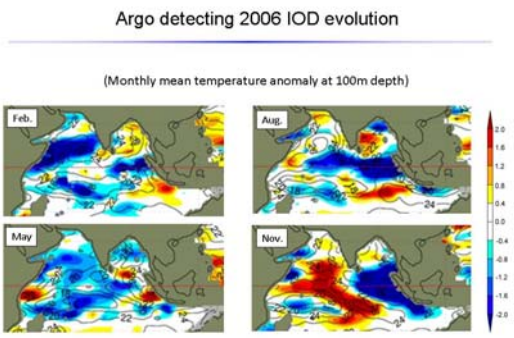


Sub-surface eastward zonal current. Similar to the EUC in the Pacific?

Relation to the zonal pressure gradient







Summary

- IndOOS is expanding

  RAMA: 27 sites of 46 sites occupied; 4 flux reference sites
  (increase 5 sites, including 1 flux site, in past year)

- Data flowing via the web and via the GTS

- Exciting science emerging

  - Ocean Responses and air-sea interactions associated with cyclone Nargis
  - Upwelling estimate in the equatorial Indian Ocean during MISMO
  - Dynamics of the equatorial currents
  - IOD variations detected by IndOOS

Science Talk by Dr. S.S.C. Shenoi

IOGOOS Annual Meeting
Perth, Australia
11-16 July 2010

Operational Oceanographic Services in IOGOOS Region

S.S.C. Shenoi

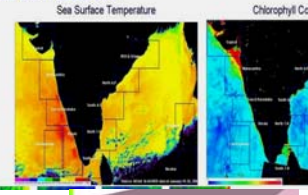
Indian National Centre for Ocean Information Services
Ministry of Earth Science, Government of India
Hyderabad-55

Potential Fishing Zone Advisory – A success story

- It is known that the fish adapts to the surrounding marine environment controlled by various physico-chemical and biological factors.
- Availability of food is an important factor which controls their occurrence, abundance and migrations in the sea.
- It is also known that they follow oceanic fronts and other ephemeral features because they concentrate food by the micro processes that develop at the frontal regions and eddies.
- Biologically rich ocean "fronts" that attract the marine life are candidates for fish aggregating zones or the potential fishing zones.

Potential Fishing Zone Advisory

Data from satellites

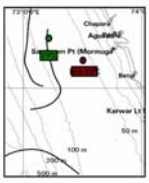


Eddies, Rings, Meanders
Tongue/Mushroom features
Upwelling ,Thermal Fronts

Potential Fishing Zone Advisory

Potential Fishing Zone Advisory

Validation of Potential Fishing Zone advisories

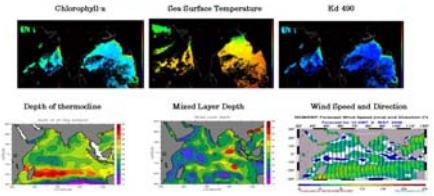


Details	PFZ	Non PFZ
Name of the boat	SLV	MDV
Type of boat	Mechanized	Mechanized
Duration of trip	01	01
Number of fishing hours	13	14
Number of hauls	01	01
NUMBER OF fishermen onboard	23	23
Total catch (kg)	2500	1000
Major species caught	Mackerel	Mackerel
Approximate cost of total catch (Rs) @ 45 Rs /kg)	1,25,000/-	50,000/-
Total expenditure in fishing operation (Rs)	19,410/- (Fuel: 8,160) (Wage 11,250)	20,730/- (Fuel: 11,730) (Wage 9000)
Net profit	1,05,590/-	29,270/-

Estimated success rate: ~ 80 %
Reduction in search time: 60 – 70 %
Increase in catch: 2 – 4 times
Increase in net profit: 2 – 4 times

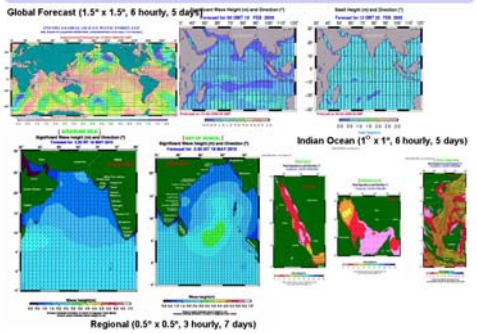
Potential Fishing Zone Advisory

Tuna forecasts

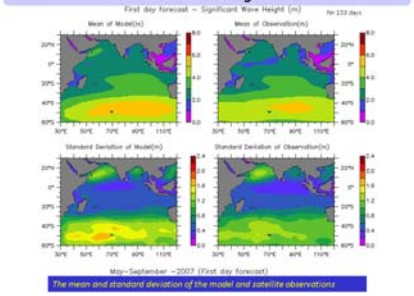


- Tuna forecast to the long-line vessels weekly twice on every Tuesday and Thursday
- Mode of dissemination is through e-mails

INDOFOS: Forecasting the waves

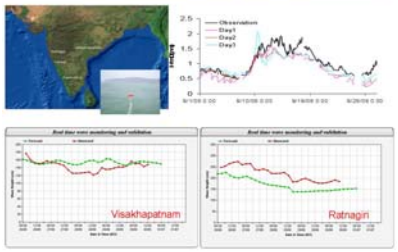


INDOFOS: Forecasting the waves

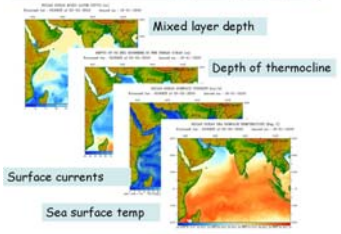


The mean and standard deviation of the model and satellite observations

INDOFOS: Forecasting the waves



Indian Ocean Forecasting System (INDOFOS)



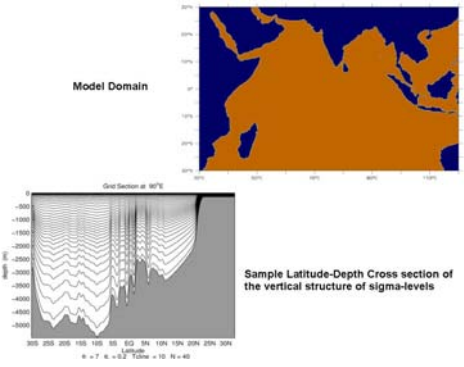
Do we need a forecasting system?

RMS Error and correlation for a persistent forecast

80.5E, EQ	RMS Error	Correlation
SST	0.32 °C	0.67
D20	9.3 m	0.74
U	26.9 (cm/s)	0.93
V	25.6 (cm/s)	0.15

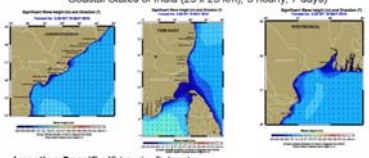
➢ 'High RMSE' and 'not so high correlations' suggests that there is a room for an alternate forecasting system

➢ However, any forecast that we issue should have a lesser RMSE and higher correlation than such a persisted forecast



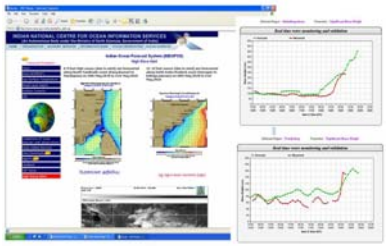
INDOFOS: Forecasting the waves

Coastal States of India (25 x 25 km), 3 hourly, 7 days)



Location Specific (3 hourly, 3 days)

Ocean State Forecast – high wave alerts



Do we need a short term forecasting system to forecast the changes in ocean parameters in the Tropical Indian Ocean?

Over the tropics, over shot time periods (say 5 days), the changes are small compared to that over the mid-latitudes and high latitudes

➢Assume that today's SST or MLD or surface currents remain the same for next five days (persistence)

If so, do we have the skill to forecast them?

If there is a skill then Error2 < Error1.

Where Error1 = OBS - persisted SST, and
Error2 = OBS - model SST.

➢In early 2010, INCOIS started an integrated Indian Ocean Forecasting System (INDOFOS) aimed at providing Ocean State Forecasts to the public and the policy makers

➢This was done by integrating an existing Wave Forecasting system with a newly developed Ocean Forecasting System based on the Regional Ocean Modeling System (ROMS), which is a state of the art Ocean General Circulation Model.

➢We use the ROMS version 3.3, developed by Rutgers University, New Jersey, USA.

➢The Model is configured for the Indian Ocean domain (30S-30N, 30E-120E) with a horizontal resolution of 0.25x0.25 and 40 vertical sigma levels

➢The boundaries in the east and south are open (where the tracers are relaxed to climatology).

➢Surface Salinity is relaxed to climatology.

➢The air-sea fluxes are computed using bulk aerodynamic formulation based on Fairall et al (1994) in the model.

➢The vertical mixing scheme is based on Large et al (1994).

➢The model uses a Jerlov I (1973) water type for computing the penetration of shortwave radiation.

➢The model was spun up for 20 years with climatological forcing and then integrated for the period 2000-2008 using QuickScat wind forcing and NCEP-Reanalysis atmospheric fluxes.

➢From 10 June 2008, the model is being forced with analyzed wind and atmospheric fluxes provided by National Centre for Medium Range Weather Forecast (NCMRWF), New Delhi from their T254L64 Atmospheric General Circulation Model.

➢From 1 July 2009, the model uses the forecasted wind and atmospheric fluxes provided by NCMRWF.

➢Every day, the model state is updated using the analyzed products from NCMRWF and then forced with the forecasted products.

➢At present, the model does not assimilate any data into it.

At present, we issue 6-hourly forecasts for the coming 5-days and update the forecasts on a daily basis.

We provide the forecasts on

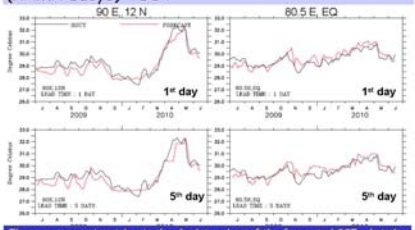
1. sea surface temperature (SST),

2. mixed layer depth (MLD),

3. surface currents and

4. depth of 20°C isotherm (as an estimate of thermocline depth).

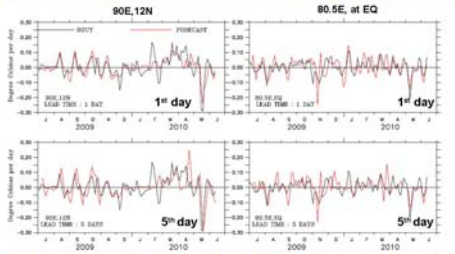
Comparison of forecasts with observations (RAMA buoys) - SST



There are some mismatches in the absolute values of the forecasted SSTs, but the patterns are quite realistic.

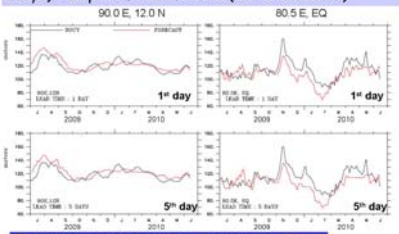
Further, the quality of the forecasts does not deteriorate substantially with time.

Day-to-day changes in the observed and forecasted SSTs



Day-to-day changes in the SST are the order of 0.1°C per day with a maximum of 0.3 °C per day.

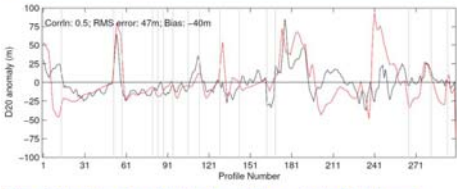
Comparison of forecasts with observations (RAMA buoys) - Depth of thermocline (20 °C isotherm)



The model shows good skill in predicting the variations in D20.

However, there are mismatches in the absolute magnitude of D20.

Comparison of 5th day D20 forecasts with the D20 measured by Argo profilers in the North Indian Ocean



Mean D20 is subtracted to highlight the variability associated with D20.

Note that the 40 m bias in the predicted D20 needs attention.

However, the model predicts the observed variation in D20 quite realistically.

Critical assessment of the quality of INDOFOS

Data used for the validation are

1. INDOFOS forecasts (daily averaged) of SST, MLD, D20 and surface current for the period 1–July-2009 to 14–June-2010

2. RAMA Buoy observations (at 12 N, 90 E and at EQ, 80.5 E)

3. GHRR daily mean SST

4. ARGO profiles (in the Arabian Sea)

Given the mismatches in the absolutes magnitudes, the forecasts are still useful if can capture the observed day-to-day variations realistically.

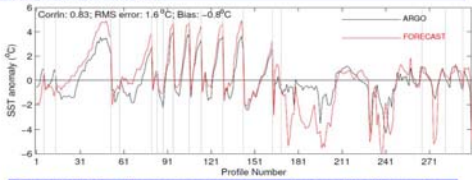
Hence, to see whether the INDOFOS forecasts capture the day-to-day variability, we computed the observed daily tendency of the parameter using a centered difference scheme and compared that with the forecast tendency.

$$\frac{\partial SST}{\partial t} = \frac{1}{2\Delta t}(SST_{t+1} - SST_{t-1})$$

$$\frac{\partial MLD}{\partial t} = \frac{1}{2\Delta t}(MLD_{t+1} - MLD_{t-1})$$

$$\frac{\partial D20}{\partial t} = \frac{1}{2\Delta t}(D20_{t+1} - D20_{t-1})$$

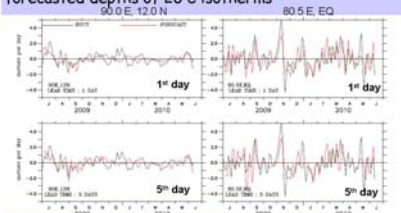
Comparison of 5th day SST forecasts with the temperature measured by Argo profilers at 7.5 m in the North Indian Ocean



Since the ARGO profilers are non-stationary, the abscissa of the diagram does not represent time. It is merely a profile identification number. 301 and profiles are considered for this study. Here, the mean SST or mean temperature at 7.5 m (in case of Argo profiles) is subtracted to highlight the variability.

Note that the model capture's the variability quite realistically. However, the model underestimates or overestimates the absolute values of SST.

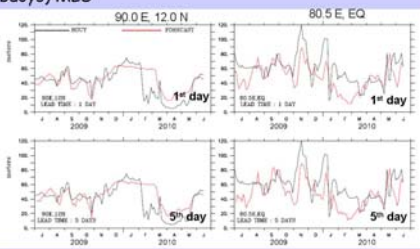
Day-to-day changes in the observed (RAMA) and forecasted depths of 20 C isotherms



Note that the variability is relatively low in Bay of Bengal, while it is significantly large in the equatorial Indian Ocean.

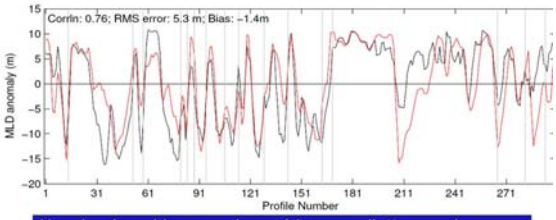
The model more or less follows the observations. The forecasts better matches with the observations when the day-to-day changes are high.

Comparison of forecasted MLD with observed (RAMA buoys) MLD



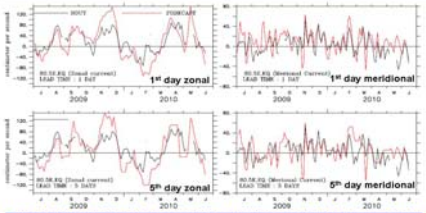
Though the model predicts the variation in MLD reasonably well on most of the occasions, there are gross errors also. The model could not predict the sharp thinning of MLD in early February 2010 in the Bay of Bengal. The error could be due to the relaxation of salinity into the climatological values in the Model.

Comparison of 5th day MLD forecasts with the D20 measured by Argo profilers in the Arabian Sea



Note that the model captures the variability very well. However, the magnitude of MLD are not accurate enough.

Comparison of forecasted surface currents with observed (RAMA buoys) currents at 80.5 E at equator



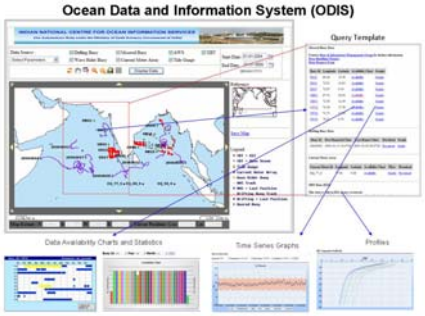
Though the model simulates the reversals in the direction of surface currents quite realistically, it grossly over estimates the magnitude of zonal current.

So, where do we stand as of now?

	Persisted Forecast		Model Forecast	
80.5E, EQ	RMS Error	Correlation	RMS Error	Correlation
SST	0.32 °C	0.67	0.46	0.61
D20	9.3 m	0.74	11.78	0.63
U	26.9 (cm/s)	0.93	44.5	0.71
V	25.6 (cm/s)	0.15	18.19	0.5

- *The statistics shows that we need to go a long way to make accurate forecasts.*
- *However, it should be kept in mind that we do not have observation every where to give a forecast based on persistence!!*
- *Hence the operational forecasts from INDOFOS are valuable.*
- *Simulation of the realistic salinity will certainly improve the forecasts. Incorporation of river runoff into the Bay of Bengal is important to simulate realistic salinities.*

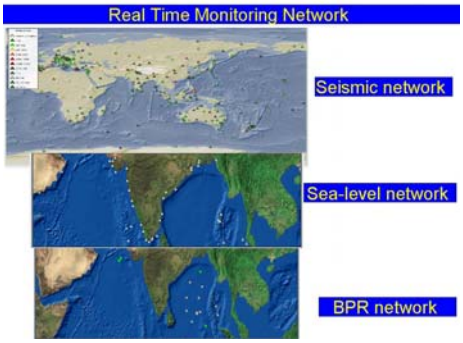
Ocean Data and Information System (ODIS)



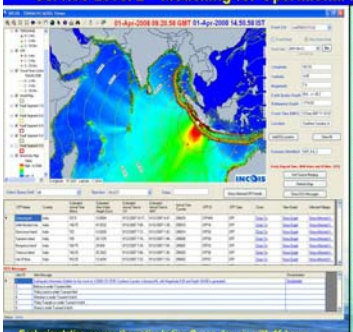
Satellite data products

Near Real Time dissemination of ocean colour products to Indian Ocean rim countries as part of an international programme

Real Time Monitoring Network



Service Level 2 - Modelling for Operational Forecasting



The TUNAMI N2 model is customized for Indian Ocean region

- This model had been extensively validated using the December 26 2004 Tsunami observations

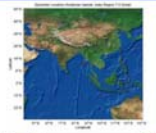
For operational forecast

- A large database of open ocean propagations scenarios
- For epicenters separated by 100 km all along two Tsunamigenic zones
- Scenarios for different magnitudes (6.5, 7.0, 7.5, 8.0, 8.5, 9.0 & 9.5) and depths (10, 20, 40, 60, 80 & 100 km)

Travel times
surge heights
directivity maps

Each simulation covers the entire Indian Ocean domain with 15 hours simulation time and a time step of 5 seconds. Out put profiles are generated at 30 m bathymetry for about 1800 coastal forecast points (CFPs) covering the entire Indian ocean rim countries.

A&N Islands Earthquake on 30 Mar 2010



A&N Earthquake of M6.9 on 30th Mar 2010 at 16:54:50 (UTC)

This event did not generate any water level changes in Indian Coasts.

Issued Bulletins

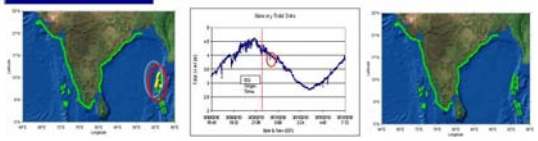
Bulletin No 1: Earthquake Information M7.0

Bulletin No 2: Watch for North Andaman; No threat for India

Bulletin No 3: No Significant Water Level Changes

No tsunami threat for A& N Islands and India main Land

INCOIS	PTWC	JMA
Tsunami Evaluation: Model Simulations do not indicate any significant change in water level at the Indian coast. There is NO tsunami threat for Indian Region	Tsunami Evaluation: PTWC issued "very small possibility of a local tsunami". Later cancelled	



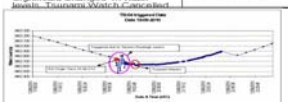
Nicobar Islands Earthquake on 12 June 2010

Nicobar Island Earthquake of Magnitude 7.5
On 12-June-2010 19:26:47 UTC, 13-June-2010 00:56:47 IST
This event did not generate any water level changes in Indian Coasts.

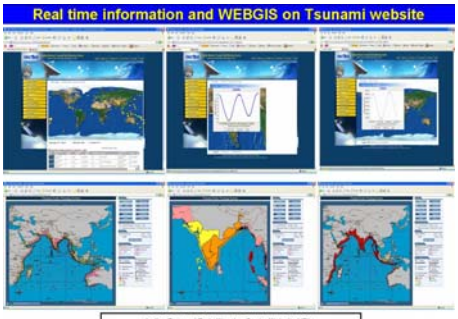
Issued Bulletins

Bulletin No 1: Earthquake Information M7.6
Bulletin No 2: Tsunami Watch is issued for North Nicobar Island;
No threat for Indian main land
Bulletin No 3: Tsunami Watch for few more islands of North Nicobar
Bulletin No 4: No Significant Water Level Changes in Real time observations;
Tsunami Watch issued for Nicobar Islands is Cancelled

INCOIS	PTWC	JMA
Tsunami Evaluation:	Tsunami Evaluation:	Tsunami Evaluation:
Based on model simulations Tsunami Watch is issued for North Nicobar Island; No threat for India main land. After the confirmation of "No Significant Changes" in water levels, Tsunami Watch Cancelled	PTWC issued A Regional Tsunami Watch for India / Indonesia / Sri Lanka / Myanmar / Thailand / Malaysia. Later cancelled.	JMA issued Regional Tsunami Watch for India/ Indonesia/ Maldives/ Sri Lanka/Myanmar/ Thailand/ Australia. Mentioned that there is a possibility of a destructive Regional tsunami in the Indian Ocean

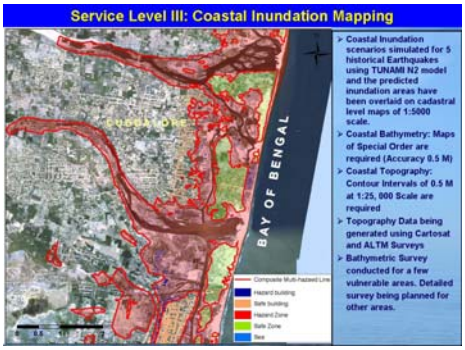


Real time information and WEBGIS on Tsunami website



Indian Tsunami Early Warning Centre Website URL:

Service Level III: Coastal Inundation Mapping



- Coastal Inundation scenarios simulated for 5 historical Earthquakes using TUNAMI N2 model and the predicted inundation areas have been overlaid on cadastral level maps of 1:5000 scale.
- Coastal Bathymetry: Maps of Special Order are required (Accuracy 0.5 M)
- Coastal Topography: Contour Intervals of 0.5 M at 1:25, 000 Scale are required
- Topography Data being generated using Cartosat and ALTM Surveys
- Bathymetric Survey conducted for a few vulnerable areas. Detailed survey being planned for other areas.

Dissemination of Potential Fishing Zone Advisories and ocean state forecasts

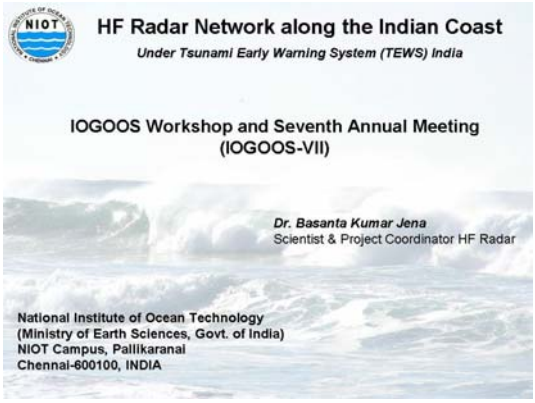
- Streamlined Operational Dissemination System
  - Telephone / Fax
  - Electronic Display Boards
  - Emails
  - Web internet
    - Maps & Text
    - Web GIS
  - SMS
  - Radio and Doordarshan
  - Local News Papers
  - Information Kiosks

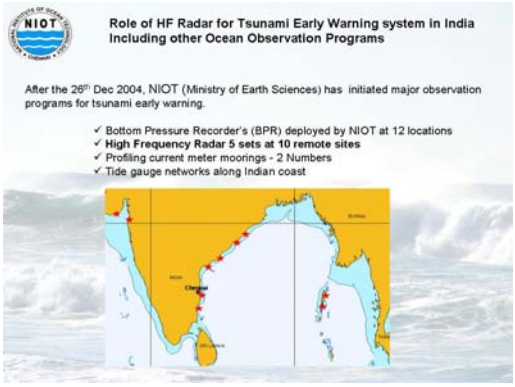
Delivered by with NGOs and fishermen societies

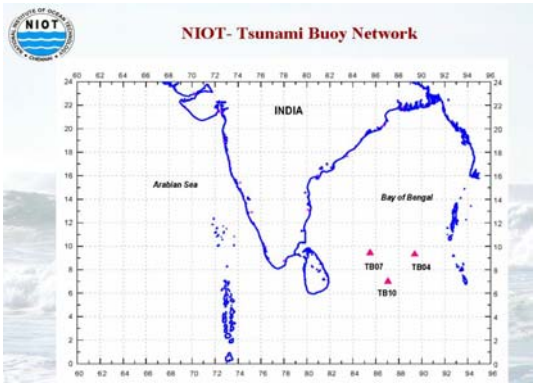
- *Advisories are provided in English and 9 Local languages, making them more acceptable and usable (Tri-lingual advisories for each sector)*

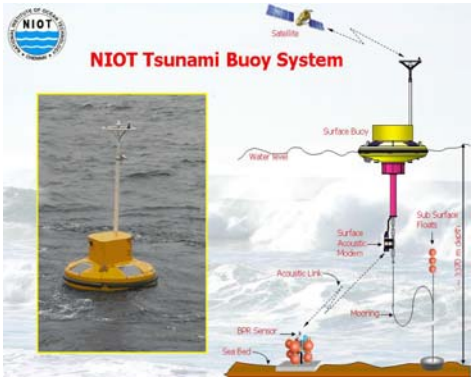
Anenxure-13

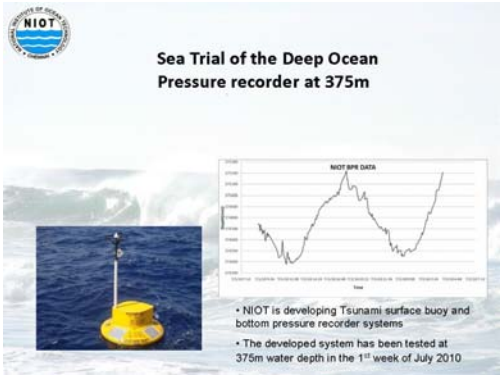
Science Talk by Dr. Basanta Kumar Jena.

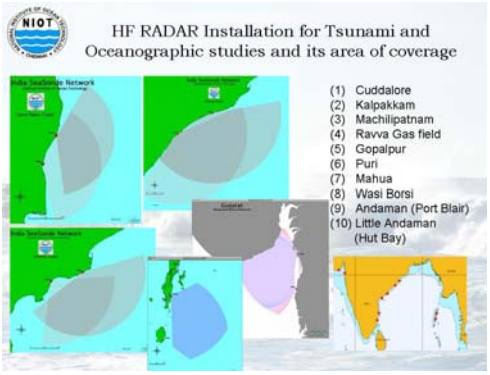


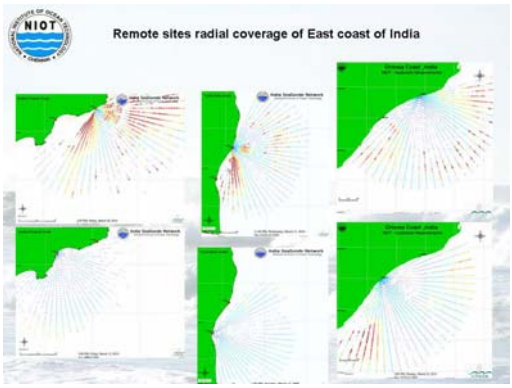


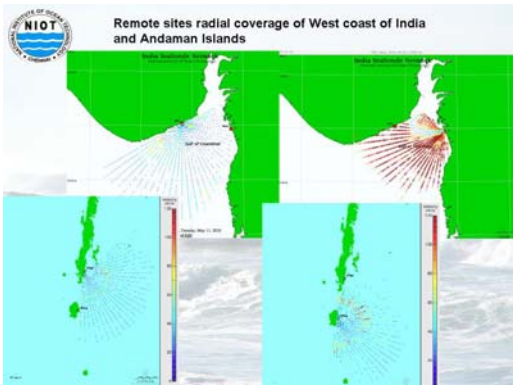


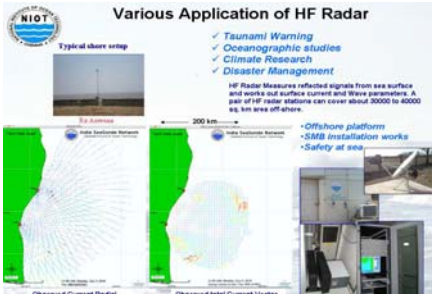


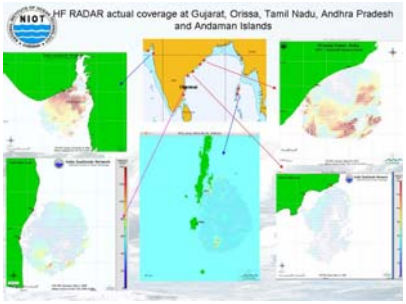


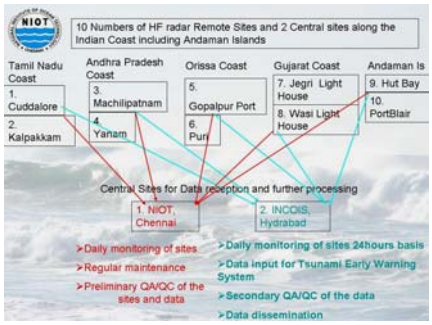


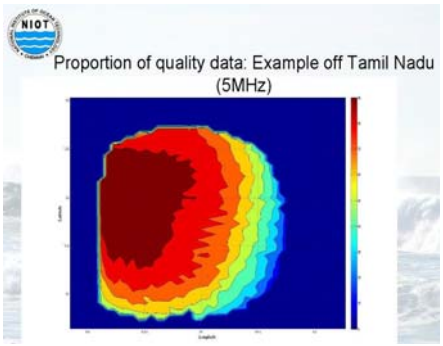


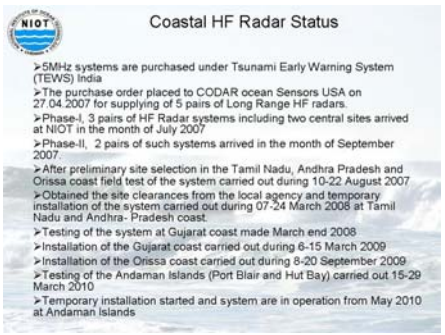


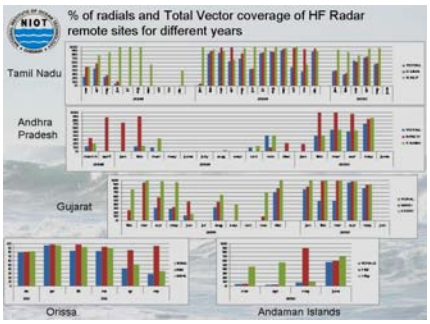

Various Application of HF Radar
Typical shore setup
✓ Tsunami Warning
✓ Oceanographic studies
✓ Climate Research
✓ Disaster Management
HF Radar Measures reflected signals from sea surface and works out surface current and Wave parameters. A pair of HF radar stations can cover about 30000 to 40000 sq. km area off-shore.
200 km
•Offshore platform
•SMB installation works
•Safety at sea

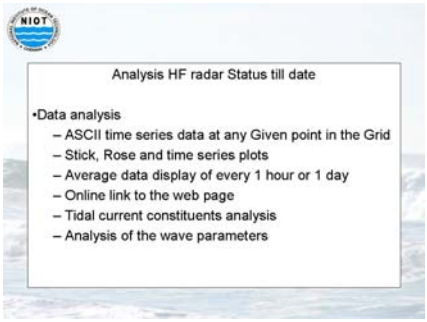

HF RADAR actual coverage at Gujarat, Orissa, Tamil Nadu, Andhra Pradesh and Andaman Islands

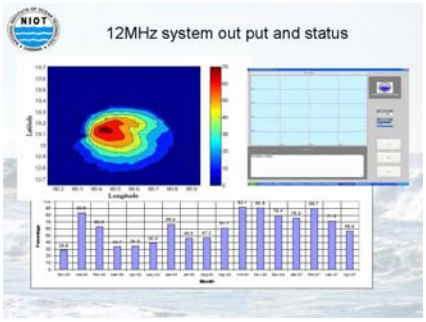

10 Numbers of HF radar Remote Sites and 2 Central sites along the Indian Coast including Andaman Islands
Tamil Nadu Coast
1. Cuddalore
2. Kalpakkam
Andhra Pradesh Coast
3. Machilipatnam
4. Yanam
Orissa Coast
5. Gopalpur Port
6. Puri
Gujarat Coast
7. Jegri Light House
8. Wasi Light House
Andaman Is
9. Hut Bay
10. PortBlair
Central Sites for Data reception and further processing
1. NIOT, Chennai
2. INCOIS, Hydrabad
➢Daily monitoring of sites
➢Regular maintenance
➢Preliminary QA/QC of the sites and data
➢Daily monitoring of sites 24hours basis
➢Data input for Tsunami Early Warning System
➢Secondary QA/QC of the data
➢Data dissemination

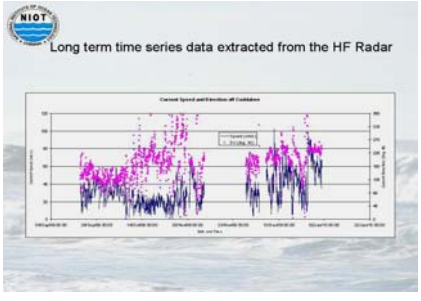

Proportion of quality data: Example off Tamil Nadu (5MHz)

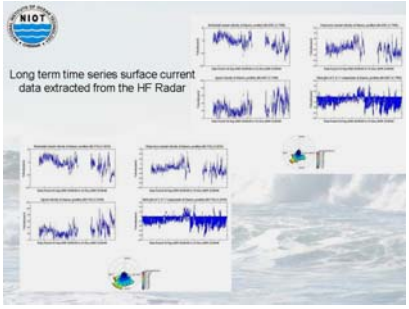

Coastal HF Radar Status
➢5MHz systems are purchased under Tsunami Early Warning System (TEWS) India
➢The purchase order placed to CODAR ocean Sensors USA on 27.04.2007 for supplying of 5 pairs of Long Range HF radars.
➢Phase-I, 3 pairs of HF Radar systems including two central sites arrived at NIOT in the month of July 2007
➢Phase-II, 2 pairs of such systems arrived in the month of September 2007
➢After preliminary site selection in the Tamil Nadu, Andhra Pradesh and Orissa coast field test of the system carried out during 10-22 August 2007
➢Obtained the site clearances from the local agency and temporary installation of the system carried out during 07-24 March 2008 at Tamil Nadu and Andhra- Pradesh coast.
➢Testing of the system at Gujarat coast made March end 2008
➢Installation of the Gujarat coast carried out during 6-15 March 2009
➢Installation of the Orissa coast carried out during 8-20 September 2009
➢Testing of the Andaman Islands (Port Blair and Hut Bay) carried out 15-29 March 2010
➢Temporary installation started and system are in operation from May 2010 at Andaman Islands

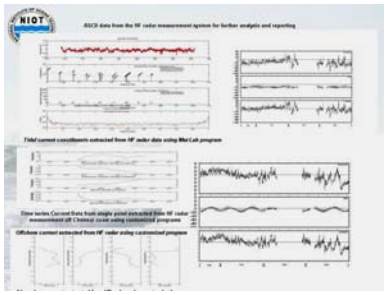

% of radials and Total Vector coverage of HF Radar remote sites for different years
Tamil Nadu
Andhra Pradesh
Gujarat
Orissa
Andaman Islands

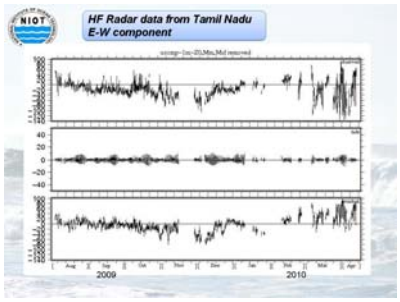

Analysis HF radar Status till date
•Data analysis
– ASCII time series data at any Given point in the Grid
– Stick, Rose and time series plots
– Average data display of every 1 hour or 1 day
– Online link to the web page
– Tidal current constituents analysis
– Analysis of the wave parameters

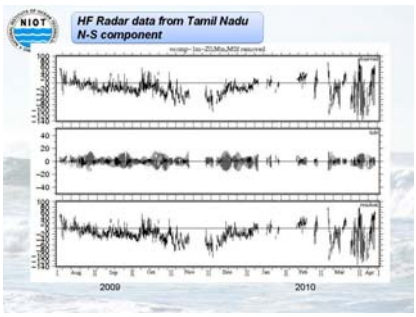

12MHz system out put and status

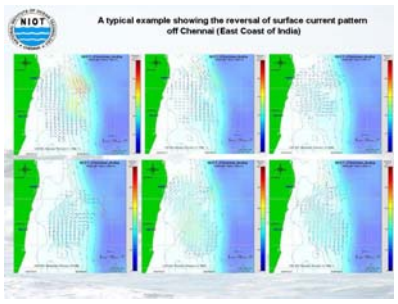

Long term time series data extracted from the HF Radar

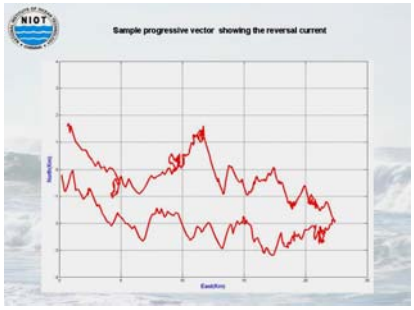

Long term time series surface current data extracted from the HF Radar

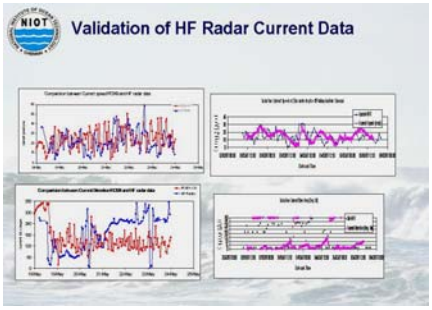


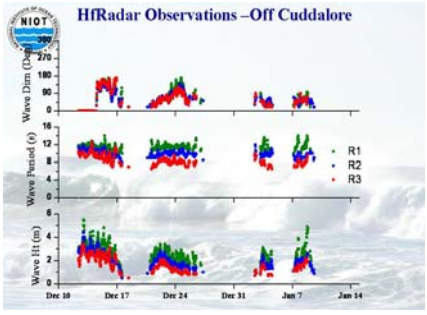

HF Radar data from Tamil Nadu
E-W component
2009
2010

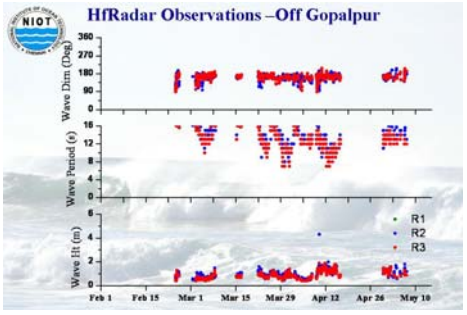

HF Radar data from Tamil Nadu
N-S component
2009
2010

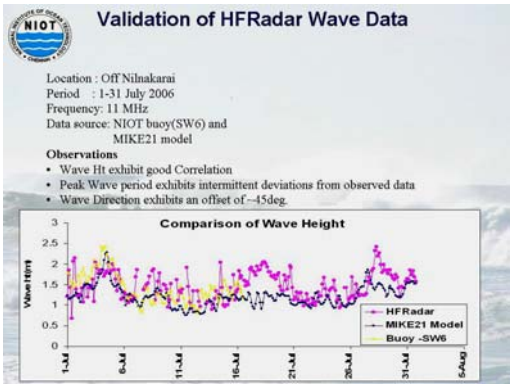

A typical example showing the reversal of surface current pattern
off Chennai (East Coast of India)

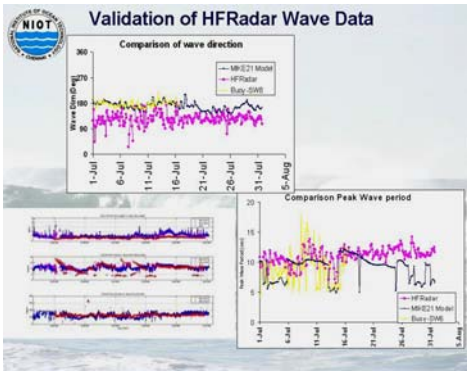

Sample progressive vector showing the reversal current

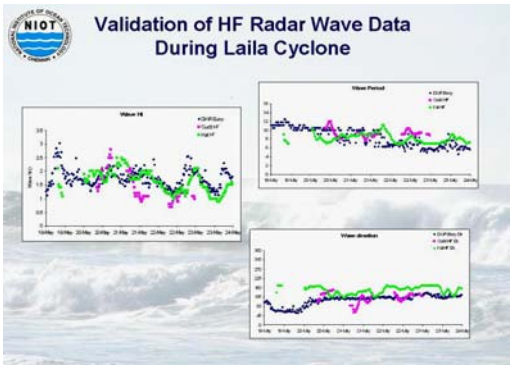

Validation of HF Radar Current Data

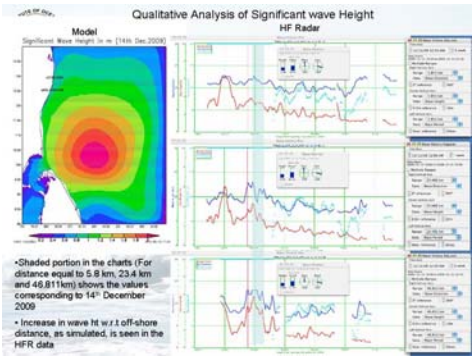

HfRadar Observations –Off Cuddalore
Wave Dim (Deg)
Wave Period (s)
Wave Ht (m)
R1
R2
R3
Dec 10
Dec 17
Dec 24
Dec 31
Jan 7
Jan 14

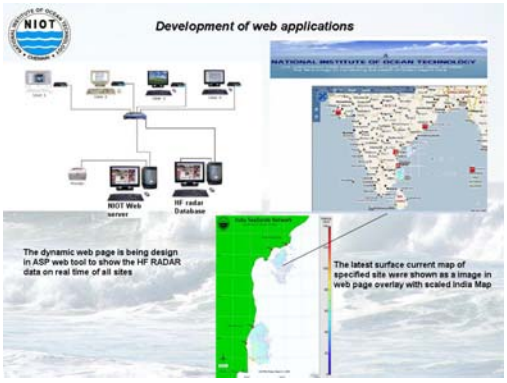

HfRadar Observations –Off Gopalpur
Wave Dim (Deg)
Wave Period (s)
Wave Ht (m)
R1
R2
R3
Feb 1
Feb 15
Mar 1
Mar 15
Mar 29
Apr 12
Apr 26
May 10


Validation of HFRadar Wave Data
Location : Off Nilnakarai
Period : 1-31 July 2006
Frequency: 11 MHz
Data source: NIOT buoy(SW6) and
MIKE21 model
Observations
• Wave Ht exhibit good Correlation
• Peak Wave period exhibits intermittent deviations from observed data
• Wave Direction exhibits an offset of –45deg.
Comparison of Wave Height
Wave Height
HFRadar
MIKE21 Model
Buoy -SW6
1-Jul
6-Jul
11-Jul
16-Jul
21-Jul
26-Jul
31-Jul
5-Aug

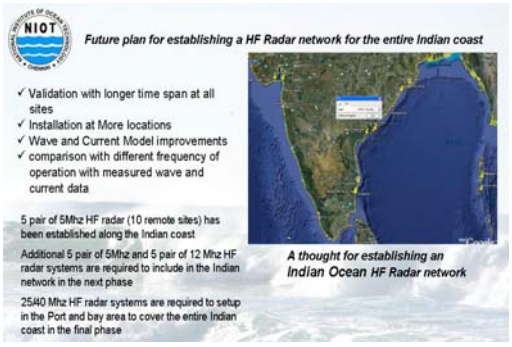

Validation of HFRadar Wave Data
Comparison of wave direction
MIKE21 Model
HFRadar
Buoy-SW6
Comparison Peak Wave period
HFRadar
MIKE21 Model
Buoy-SW6

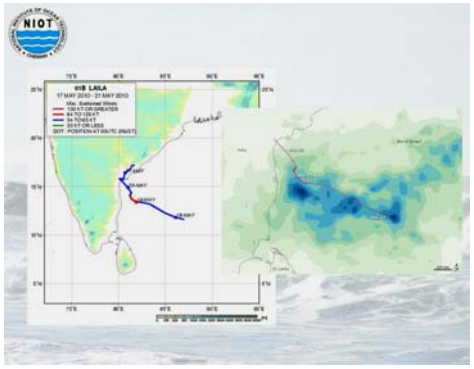

Validation of HF Radar Wave Data
During Laila Cyclone

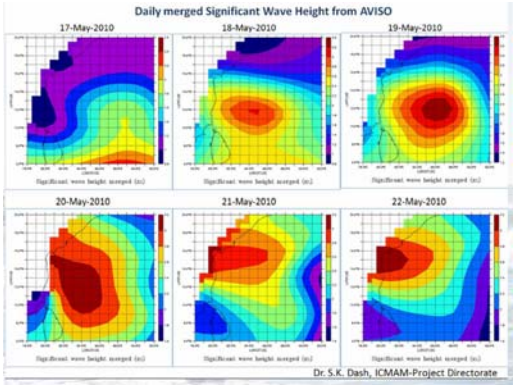

Qualitative Analysis of Significant wave Height
Model
HF Radar
•Shaded portion in the charts (For distance equal to 5.8 km, 23.4 km and 46.811km) shows the values corresponding to 14th December 2009
• Increase in wave ht w.r.t off-shore distance, as simulated, is seen in the HFR data

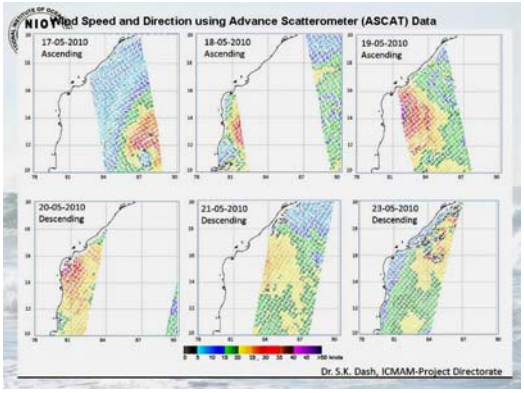

Development of web applications
NIOT Web server
HF radar Database
The dynamic web page is being design in ASP web tool to show the HF RADAR data on real time of all sites
The latest surface current map of specified site were shown as a image in web page overlay with scaled India Map

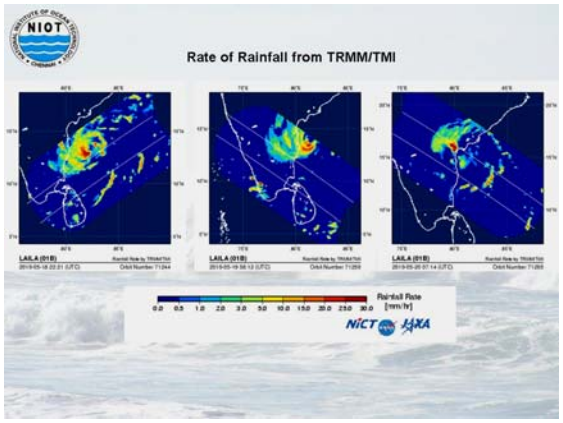

Validation plan for HF radar
SURFACE FLOAT
DROGUE

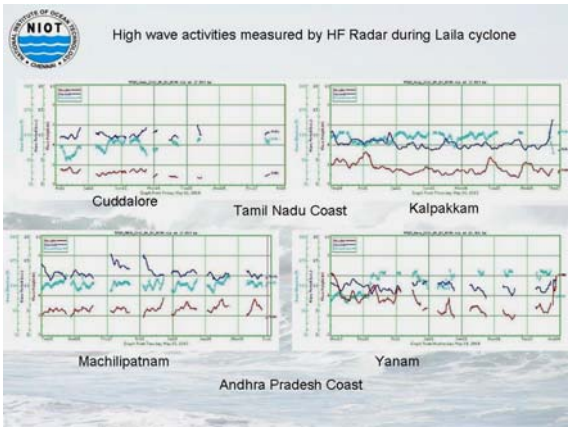

Future plan for establishing a HF Radar network for the entire Indian coast
✓ Validation with longer time span at all sites
✓ Installation at More locations
✓ Wave and Current Model improvements
✓ comparison with different frequency of operation with measured wave and current data
5 pair of 5Mhz HF radar (10 remote sites) has been established along the Indian coast
Additional 5 pair of 5Mhz and 5 pair of 12 Mhz HF radar systems are required to include in the Indian network in the next phase
2540 Mhz HF radar systems are required to setup in the Port and bay area to cover the entire Indian coast in the final phase
A thought for establishing an Indian Ocean HF Radar network

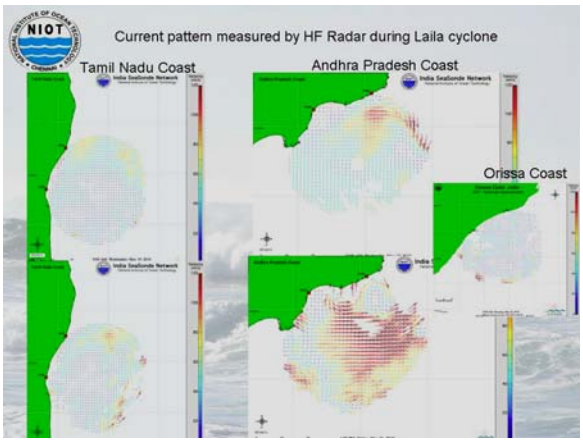

OIB LAILA


Daily merged Significant Wave Height from AVISO
17-May-2010
18-May-2010
19-May-2010
20-May-2010
21-May-2010
22-May-2010
Dr. S.K. Dash, ICMAM-Project Directorate


Wind Speed and Direction using Advance Scatterometer (ASCAT) Data
17-05-2010 Ascending
18-05-2010 Ascending
19-05-2010 Ascending
20-05-2010 Descending
21-05-2010 Descending
23-05-2010 Descending
Dr. S.K. Dash, ICMAM-Project Directorate

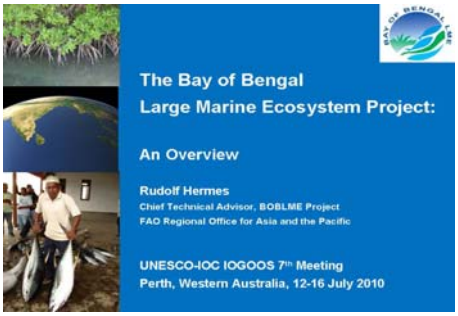

Rate of Rainfall from TRMM/TMI
Rainfall Rate
[mm/hr]
NiCT
JAXA

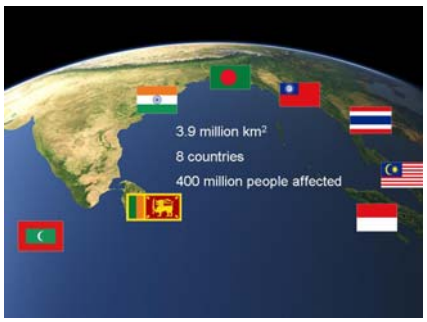

High wave activities measured by HF Radar during Laila cyclone
Cuddalore
Tamil Nadu Coast
Kalpakkam
Machilipatnam
Yanam
Andhra Pradesh Coast

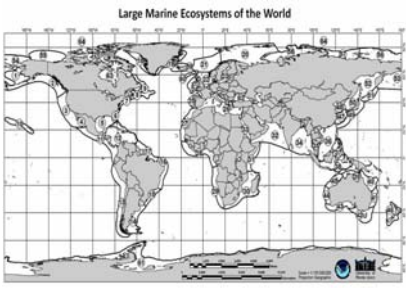

Current pattern measured by HF Radar during Laila cyclone
Tamil Nadu Coast
Andhra Pradesh Coast
Orissa Coast

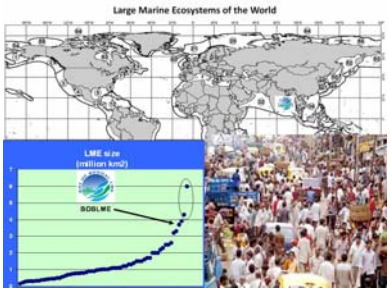
Annexure-14

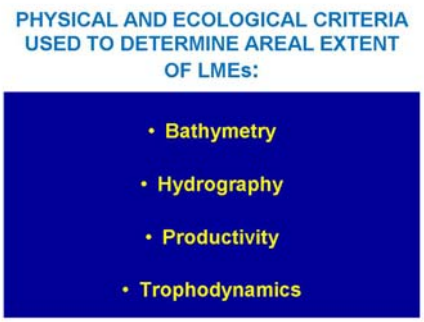
Science Talk by Dr. Rudolf Hermes

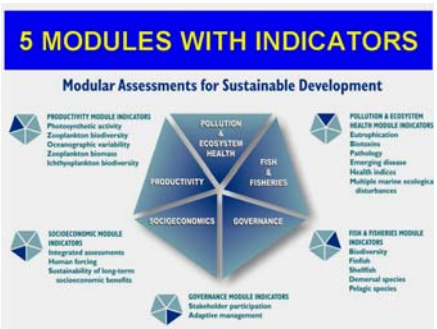












Productivity Module Indicators

1. Photosynthetic activity
2. Zooplankton and Ichthyoplankton biodiversity
3. Zooplankton biomass
4. *Oceanographic variability*

The BOBLME Project has five components

Component 1: Strategic Action Plan

- Finalize Transboundary Diagnostic Analysis (TDA)
- Establish BOB management arrangements
- Devise a sustainable financing mechanism
- Formulation and adoption of Strategic Action Plan (SAP)

Component 2:
Coastal/Marine Natural Resources Management and Sustainable Use

- Promote community-based management
- Improve policy harmonization
- Devise regional fishery assessments and management plans (3)
- Collaborative critical habitat management

Component 3:
Improved Understanding and Predictability of the BOBLME Environment

- Improved understanding of large-scale processes and dynamics affecting the BOBLME
- Promote use of MPAs to conserve regional fish stocks
- Improved regional cooperation with regional and global assessment and monitoring programmes

Component 4:
Maintenance of Ecosystem Health and Management of Pollution

- Establishment of an effective ecosystem indicator framework
- Develop a regional approach to identifying and managing important coastal pollution issues

Component 5: Project Management

- Establishment of the Regional Coordination Unit (RCU)
- Monitoring and evaluation system
- Project information and dissemination system

Ecosystem Approach to Fisheries (EAF)

FAO definition (simplified)

An integrated approach to fisheries to balance diverse societal objectives, within ecologically meaningful boundaries

The many approaches to ecosystem management

- Integrated Coastal Management (ICM)
- Coastal Zone Management (CZM)
- Integrated Coastal Resource Management (ICRM)
- Integrated Coastal Area Management (ICAM)
- Large Marine Ecosystem Management (LME)
- Ecosystem-based Management (EBFM)
- Wealth-based Fisheries Management (WBFM)
- Sustainable Livelihoods Approach (SLA)
- Ecosystem Approach to Fisheries (EAF)

The Ecosystem Approach to Fisheries (EAF) is a way of achieving sustainable development

The Bay of Bengal Large Marine Ecosystem (BOBLME) Project is an opportunity to implement the Ecosystem Approach to Fisheries

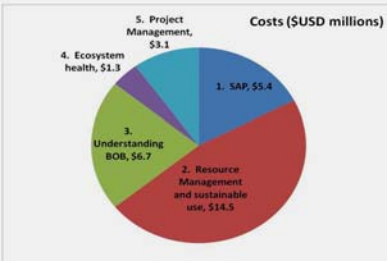
Expected Outputs of the BOBLME Project

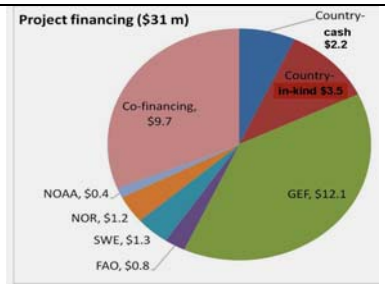
1. Transboundary Diagnostic Analysis
2. Establishment of an institutional arrangement
3. Commitment from the BOBLME countries to implement a Strategic Action Programme (SAP)

Expected Outcomes of the BOBLME Project

- **Stronger governance:**
  - Improvements in policy development
  - Processes for planning and dialogue
- **Improved resource management:**
  - Better understanding of small-scale fisheries issues
  - Co-management - Multi-sectoral involvement
  - Healthier ecosystems
  - Sustainable fisheries
- **Improved well-being, greater resilience of coastal communities**
- **Better knowledge of:**
  - Fisheries for hilsa and Indian mackerel
  - BOBLME's large-scale processes and ecology
  - Likely effects of climate change
  - Basic ecosystem health indicators in the BOBLME

BOBLME: 8 Countries, 5 Years





FAO is GEF Agency and project execution agency

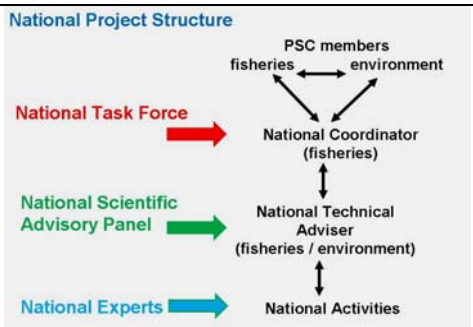
FAO provides:

- **Staff administration**
- **Project services – travel, purchasing etc**
- **Budget and financial management and reporting**
- **Technical adviser**
- **Project Task Force**
- **Temporary accommodation for the RCU**

Project Activities

- 486 Workshops
- 77 Studies
- 129 International consultant months
- 259 National consultant months
- Data collection
- Short courses, training
- Communications
- Monitoring and evaluation
- Reporting

National Project Structure



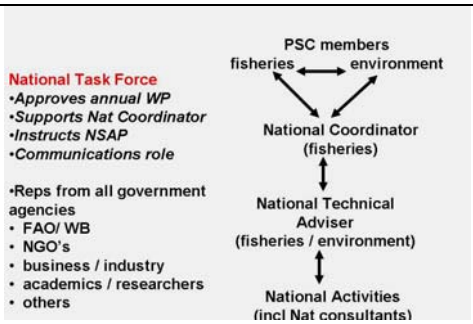
National Project Structure

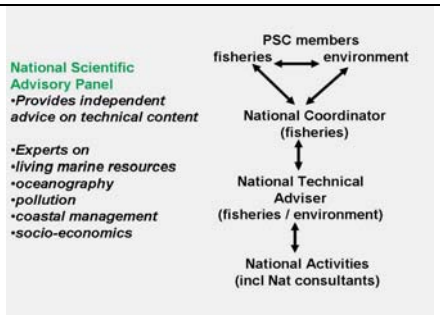
Project Steering Committee
Two high level representatives from each country (Environment and Fisheries)

provides overall guidance on the project, promotes the project at all levels

Regional Coordination Unit

National Coordinator, National Technical Advisor





What has been achieved over the last year?

- There is a plan for the completion of the Transboundary Diagnostic Analysis (TDA) and update on-going
- Regional Inception Workshop agreed that the Project and its activities were still relevant
- National Inception Workshops have been completed in six countries
- Project Steering Committee (PSC) adopted a Regional Work plan for 2010
- Website is up and running and a Communication Strategy adopted

What has been achieved over the last year?

- The BOBLME Project offices will be located in Phuket
- Many partners have been engaged
- Training provided in EAF, livelihoods, stock assessment
- Regional Workshop on Fisheries Data and Statistics
- Regional Workshop on Land-based Pollution

Challenges (2) - Communications

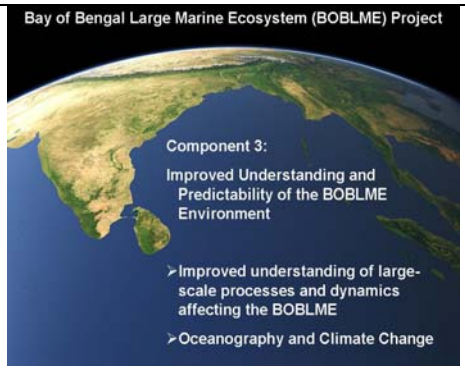
…the science – management interface

Enhancing communications

Communications is a full-time role, there is a need to:

- Get the Project messages to stakeholders, governments, global audiences (with other LME's) - films, articles, posters, caps-bags-t shirts..
- Building support for the Project
- Promoting the Ministers promoting the Project
- Promoting the National Coordinators
- Promoting the results of the Project in each country
- Exciting the next generation

Challenges (2) – Communications



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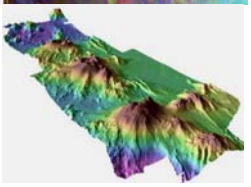
3. Zooplankton biomass
4. *Oceanographic variability*



BOBLME tasks as envisaged (ProDoc):

- inventory and collection of relevant datasets that measure past variability in the BOBLME and its links to system productivity (e.g. data on monsoonal related phenomena, meteorology, oceanography, ocean colour, and primary productivity);
- completion of 8 national retrospective studies; and
- regional workshops to identify and assemble datasets, identify data gaps, and plan relevant studies.

➢ Capacity building
➢ Adaptation to climate change
➢ Exchange of oceanographic data and information
➢ Ecosystem mapping and monitoring of indicators of ecosystem health

Annexure-15

IOGOOS Secretariat Report (December 2008 – June 2010)

Sl. No.	Item	Status / Progress
1.	**IOGOOS Annual Meeting**	
1.1	IOGOOS VI Report	• Finalised and circulated the IOGOOS VI Annual Report.
1.2	The IOGOOS Secretariat was requested to interact with the potential hosts to finalise the venue and the dates of the next Annual Meeting	• Action Completed
1.3	Conduct of IOGOOS VII	• Circular, Invitations, Agenda, Funding for IOGOOS VII. • Funding from IOC Perth Office (AUD 15, 000) to partially / fully sponsor 05 participants.
2.	**Capacity Building**	
2.1	IOGOOS Secretariat was asked to approach IOC / UNESCO for Capacity Building under the framework of IOGOOS projects	• "International Capacity Development Program: Seminar and Proposal-writing workshop for Marine related Institutions at Universiti Malaysia Sabah, Malaysia during December 10 – 14, 2008. IOC UNESCO has sponsored 05 Participants from IOGOOS Coastal Projects. • COAST MAP IO Workshop on Drafting Project Proposal to International Financial Institutions held at Hyderabad, INDIA during November 4-7, 2009. 17 participants from 11 countries have participated in the meeting out of which 08 representatives from IOGOOS member countries. • IOGOOS, through IOC/UNESCO Perth Office has sponsored 05 delegates from the Indian Ocean Rim countries for their participation in the SAFARI (Societal Applications in Fisheries and Aquaculture using

		Remotely-sensed Imagery) International Symposium on "Remote Sensing and Fisheries" held at Kochi, India during February 15-17, 2010 and ChloroGIN General Meeting during February 18 – 19, 2010. • Circulated the announcement of C V Raman International Fellowship for African Researchers, announced by Department of Science and Technology (DST), Govt. of India, to the IOGOOS Members from the African Countries.
3.	**IOGOOS Projects**	
3.1	Secretariat to provide a critical review and assessment of all feasible existing and proposed IOGOOS projects as well as unfeasible existing or proposed projects at the next IOGOOS meeting, to facilitate decisions that would need to be made by members on continuance or otherwise of all projects, with a view to then revising and updating the project listing on the IOGOOS website	• Key stone Ecosystem project need to be dropped or either need to identify an active leader. • Shoreline change project has becoming in-active due to no response from the Member countries. PL may be tasked for coordination with the member countries for their participation. • Chlorophyll_a Mapping project is progressing well. The Progress will be made by Dr. T. Srinivasa Kumar.
4.	**Governance**	
4.1	Reflect the creation of Co-secretary post and renewal of Chair position with Dr. Shailesh Nayak.	• Action Completed
4.2	The Chair tasked the Secretariat to (i) coordinate a letter of thanks and appreciation (through the Chair) to Dr Smith on his retirement as IOGOOS Officer and (ii) coordinate the process for Dr Smith's replacement out of session, before the next IOGOOS meeting	• Action Completed. • Notified the vacancy of Dr. Neville's position. Nominations are tabled for discussion under Item No. xiii of IOGOOS Annual Meeting.
4.3	IOGOOS Officers	• The secretariat sent out the status paper and requested nominations for the positions of IOGOOS Chair and Officer. The status is attached as Annexure – 1. Will be discussed as Agenda Item xiii of the Annual

		Meeting.
4.4	IOGOOS Members	• Sultan Qabbus University, Sultanate of Oman is willing to become an IOGOOS Member. However, the SQU has requested for a change in nomenclature. Instead of calling "MoU" , they would like to call as "Agreement" so that they could obtain necessary approvals. • Bay of Bengal Large Marine Ecosystem (BOBLME), a project of FAO, is willing to become an Associate Member.
5.	**Finance**	
5.1	Membership Fees for 2009-10	• Sent out requests to Members for remittance of the Annual Membership fee for the period 2009-10.
5.2	Audit	• Completed Financial Accounting and Audit for the Period December 2008 – June 2010). • Statement of Account is being submitted for verification and approval. The status is attached as Annexure – 2. Will be tabled as Agenda Item xi of the Annual Meeting

Specific actions with respect to IOP, SIBER, Modelling and Remote Sensing project initiatives will be presented by the respective project leaders.

Annexure-16

IOGOOS Related Activities by Dr. Nick D' Adamo, IOC Perth Office

Annexure-17

IOP Report for IOGOOS by Dr. Yukio Masumoto

IOP Report for IOGOOS

The Panel is coordinating implementation of the Indian Ocean Observing System (IndOOS) and research activities using data from IndOOS and modeling outputs.

1. Implementation of IndOOS

Implementation of IndOOS is in progress. Its critical component RAMA, the Research moored Array for African-Asian-Australian Monsoon Analysis and prediction, is expanding steadily. As of July 2010, 27 of the RAMA mooring sites out of 46 planned locations are already occupied (59%), with the equipment and/or ship time contributions from China, France, India, Indonesia, Japan, and the US, as well as from regional programs such as ASCLME. One meridional section at 90°E and one zonal section along 8°S are completed. Several additional moorings are expected to be deployed in 2010 and the implementation rate will be close to 70% of the full array by the end of 2010. Data from IndOOS are available through the IndOOS Data Portal site at http://www.incois.gov.in/Incois/iogoos/home_indoos.jsp

1. Implementation of IndOOS (cont.)

New data obtained by IndOOS has already helped to improve our understanding of various phenomena of climate importance, such as;

i) the ocean dynamics associated with Indian Ocean Dipole,
ii) dynamics of the equatorial currents at intra-seasonal, semi-annual and annual time scales, and
iii) upper ocean response (SST and mixed layer depth) to MJO and cyclone forcing and its potential feedbacks.

The data stream from IndOOS will be vital for advancing monsoon research, and leads to improvements in seasonal prediction skill in the African-Asian-Australian monsoon region.

More detailed information, and the full list of publications can be obtained at the IndOOS bibliography site at http://www.clivar.org/organization/indian/IndOOS/biblio.php.

2. Cooperation with SIBER

IOP has been developing a strong linkage with the Sustained Indian Ocean Biogeochemical and Ecological Research (SIBER) project, and Dr. Raleigh Hood is now a liaison member of IOP from SIBER group.

SIBER and IOP have developed a plan for deployment of biogeochemical sensors on RAMA moorings (Appendix IV of the SIBER Science Plan and Implementation Strategy). This plan includes guidance for site selection, potential sensors, installation options and priorities, and a summary of key questions that can/should be addressed. A prototype biogeochemical sensor package has been constructed and is slated for deployment in the western Indian Ocean in 2010.

Dedicated presentations and discussions focusing on future biogeochemical sensor deployments and means to secure funding for these sensors are planned for a joint IOP/SIBER session in Perth.

3. IndOOS Resources Forum

A business plan of IndOOS Resources Forum (IRF) was developed, and it was adopted by IOGOOS. IRF is a critical activity to secure the ship-time and other resources for IndOOS. The IRF members will be executive-level managers from agencies and national or international programs that are currently supporting the development of IndOOS. During July 2010 in Perth, Australia, meetings of IO-GOOS-VII, the SIBER SSC, and IOP-7 will be held jointly, in order to enhance links and mutual collaborations among the projects. The first IRF meeting will immediately follow, with inputs from the IO-GOOS/SIBER/IOP meetings. This series of meetings will contribute to further development of IndOOS, regional/coastal observing systems in the Indian Ocean, and related research activities.

4. Cooperation with regional/coastal observing systems

IOP tries to strengthen the cooperation among all the Indian Ocean regional observing systems that provide channels for applications of IndOOS data.

5. Coordinated field programs/process studies

IOP has been coordinating and endorsed the Thermocline Ridge of the Indian Ocean (TRIO) project initiated by the French ocean community, and CINDY/DYNAMO program led by Japanese/American scientists. TRIO will explore air-sea interactions at synoptic (cyclones and tropical storms), intraseasonal (Madden-Julian Oscillation) and interannual timescales in the 5°S-15°S band of the Indian Ocean, while CINDY2011/DYNAMO is focusing on variations at the intraseasonal timescale in the equatorial central Indian Ocean. Both programs will operate intensive observations on air-sea interactions in the Indian Ocean, and carry out modeling studies and analysis of existing data. The observational components of these two programs will also help the implementation of RAMA.

Annexure-18

IRF Agenda by Dr. Gary Meyers

IRF Agenda

See Agenda discussion paper at
INCOIS (home page) > IOGOOS > IRF-1

- Overview existing bilateral arrangements
- Progress in regional capacity building for operational oceanography models
- Data on past and future need for ship-time
- Present status of IndOOS
- Excerpt from SIBER Science and Implementation Plan with technical details on enhancement of RAMA w/BGC sensors

Session 1 Plenary with IOGOOS, IOP, SIBER

0900-0920 Plenary Talk by Chief Scientist of Western Australia
0920-0940 Plenary Talk by IOGOOS Chair
0940-1000 Plenary Talk by IOP Chair
1000-1020 Plenary Talk by SIBER Chair
1020-1030 Plenary Talk by IRF Convenor

1030-1100 Morning tea

Session 2 Network building (by invitation)

1100-1115 Welcome and Introductions
1115-1200 IRF business (45 minutes)
--Elect chairman for 2 years
--Discuss objectives
--Modus operandi e.g. how often to meet
1200-1300 IRF members briefly describe contributions to IndOOS and interests in observing the Indian Ocean from a personal, or agency-, or national perspective

1300-1400 Lunch

Session 3 The need for resources

1400-1420 Discussion of societal benefits
1420-1440 Key science issues and future resource-needs
Chair Indian Ocean Panel
Chair SIBER
Convenor

1500-1530 Afternoon tea

Session 4 Providing resources

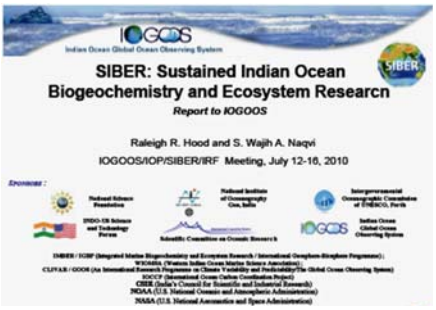
1530-1700 Discussion of resourcing issues
- Sustaining RAMA. Ship-time is critical

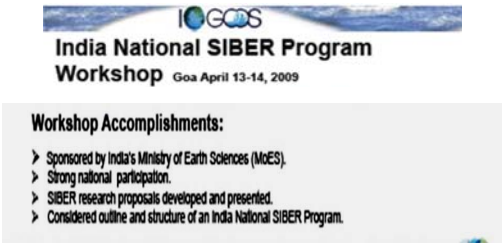
Members will brief the Forum on how ship time is allocated in each country and agree common action.
- Enhancement of RAMA with BGC sensors
- Other issues

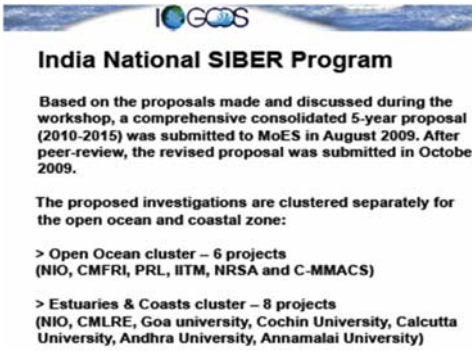
1700-1715 Next meeting, review of post-meeting actions, closing

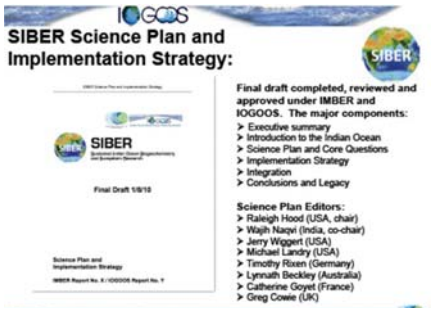
Annexure-19

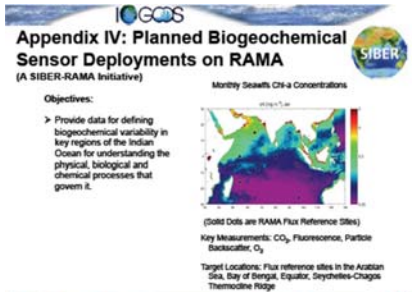
Report on SIBER-1 Activities by Dr. Raliegh Hood

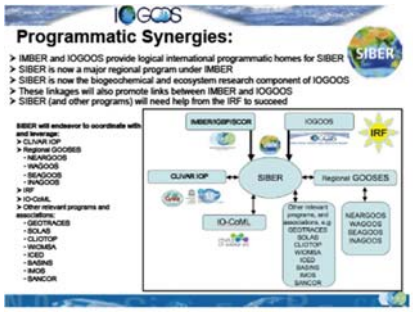












Interim SIBER Science Scientific Steering Committee:

1) Raleigh Hood (Chair, US, biogeochemical modeling)
2) Wajih Naqvi (co-Chair, India, N-cycling and microbiology)
3) David Vousden (South Africa, director ASCLME, human impacts and management)
4) Lynnath Beckley (Australia, fish and higher trophic levels)
5) Hiroshi Kitazato (Japan, biology and ecology of deep-sea meiobenthos)
6) Adnan Al-Azri (Oman, phytoplankton and DOM dynamics)
7) Jerry Wiggert (USA, physical-biogeochemical modeling)
8) Mike Landry (US, zooplankton and food web dynamics)
9) Greg Cowie (UK, benthic biogeochemistry)
10) Catherine Goyet (France, carbon cycling and biogeochemistry)
11) Timothy Rixen (Germany, carbon biogeochemistry)
12) Dwi Susanto (US/Indonesia, physical oceanography and remote sensing)

Proposed Expanded SIBER Science Scientific Steering Committee:

1) Raleigh Hood (Chair, US, biogeochemical modeling)
2) Wajih Naqvi (co-Chair, India, N-cycling and microbiology)
3) David Vousden (South Africa, director ASCLME, human impacts and management)
4) Lynnath Beckley (Australia, fish and higher trophic levels)
5) Hiroshi Kitazato (Japan, biology and ecology of deep-sea meiobenthos)
6) Adnan Al-Azri (Oman, phytoplankton and DOM dynamics)
7) Jerry Wiggert (USA, physical-biogeochemical modeling)
8) Mike Landry (US, zooplankton and food web dynamics)
9) Greg Cowie (UK, benthic biogeochemistry)
10) Catherine Goyet (France, carbon cycling and biogeochemistry)
11) Timothy Rixen (Germany, carbon biogeochemistry)
12) Dwi Susanto (US/Indonesia, physical oceanography and remote sensing)
13) M. Ravichandran (India, physical oceanography, Argo program, INCOIS)
14) Mitrasen Bhikajee (Mauritius, director MOI, marine biology)
15) Shiham Adam (Maldives, CLIOTOP rep., fisheries assessment and management)
16) Marina Levy (France, physical-biogeochemical modeling, mesoscale dynamics)
17) Somkiat Khokiattiwong (Thailand, IOGOOS representative, marine biology)

Annexure-20

Report on Indian Ocean Core Remote Sensing Project by Dr. T. Srinivasa Kumar

Indian Ocean Core Remote Sensing Project ChloroGIN-IO

By
T. Srinvasa Kumar, Ph.D.
srinivas@incois.gov.in

IOGOOS VII

July 12 -16, 2010
Perth

Project Partners

Dr. T. Srinivasa Kumar, INCOIS
Dr Kamal Dharmasiri TENNAKOON, NARA, Sri Lanka Kanthi Yapa, University of Ruhuna, Sri Lanka
Dr Greg M WAGNER, University of Dar Es Salaam, Tanzania Dr. Margareth Kyewalyanga
Mr Ali Shareef National Meterological Centre, Male, Maldives
Dr Johnson Kazungu Kenya Marine & Fisheries Research Institute, Mombassa, Kenya
Dr Abbas Nobakhti Executive Deputy of INCO, Tehran
Dr Y.V.B. Sarma MSF CAMS Sultan, Qaboos University
Mr Somkiat Khokiattiwong Department of Marine and Coastal Resources, Phuket Marine Biological Center, Phuket, Thailand

Background

Chlorophyll has been identified by GOOS as one of the most important properties to be measured in a global observing system along with Total Suspended Matter (TSM), water clarity (K490) and Sea-Surface Temperature (SST) → Report No. 148

The GOOS Coastal Panel has recommended that GOOS Regional Alliances come forward with proposals for Pilot Projects for Coastal GOOS.

The Chlorophyll Global Integrated Network (ChloroGIN) project aims to promote *in situ* measurement of chlorophyll in combination with satellite derived estimates. The broad aim is to provide to a web server, regular ocean colour and SST images (daily, weekly and monthly, depending upon each region's needs and conditions)

- Daily Images of Chl-a, SST, Kd-490 have been identified as Important RS Products that are required by IOGOOS Members
- IOGOOS V endorsed chlorophyll mapping project for scientific understanding and societal benefits in the Indian Ocean Region
- The IOGOOS-VI identified the Indian National Centre for Ocean Information Services (INCOIS) as the nodal agency for dissemination of satellite derived ocean colour products to Indian Ocean Countries.
- Recommended collaboration with international projects such as ChloroGIN

Vision & Objectives of ChloroGIN

Vision:
ChloroGIN is an international network to assess the state of marine, coastal and inland-water ecosystems for the benefit of society; promoting for that purpose in-water observations in synergy with ocean-colour and related satellite observations.
Objectives:
1. To provide time series of ecosystem indicators for management of fisheries, aquaculture, coastal To provide time series of ecosystem indicators for management of fisheries, aquaculture, coastal zones and inland water bodies.
2. To enhance *in situ observations to characterise local conditions, including sub-surface* water properties for assessing water quality, ecological status and potential for human use. Essential also for ground-truthing of satellite observations.
3. To develop and supply value-added products needed for management by local authorities, regional and national governments.
4. To develop tools and techniques for analysis of ChloroGIN products for assessing regime shifts, climate change and climate variability, and the status of fisheries, ocean, coastal and inland water ecosystems, as a basis for policy implementation.
5. To communicate ChloroGIN products of ecosystem state widely to potential users in society and in policy-making bodies.
6. To help train and develop a new generation of scientists with the skills to develop and maintain the ChloroGIN vision.
7. To achieve these objectives by means of an international network of both developed and developing countries.
8. To liaise and cooperate with other Earth Observation groups nationally, regionally and internationally.

IO Core Remote Sensing Project Work Plan

1. Three individual pilot projects on Keystone Ecosystems, Shoreline Change Monitoring, real-time chlorophyll mapping be amalgamated to form one project, using remote sensing as a unifying theme, with the project named as the Indian Ocean Core Remote Sensing Project
2. Provision of Remote Sensing Products required for IOGOOS Pilot Projects
3. Identification of sites for the monitoring of coral reef, mangroves and shoreline changes and Conduct pilot studies on the test sites for enhancing Capacity Building
4. Three IOGOOS pilot projects recast into business-like proposals and to be presented to the potential donor agencies.

1. Initiation of the Indian Ocean real time chlorophyll-a mapping sub-project
   - Collate the requirements of member countries for real time maps of environmental parameters, such as SST, chlorophyll-a, total suspended sediments and Kd_490 products
   - Set up the processing chain and provide products
   - Develop the methods for the project and circulate to members
   - Develop a plan for in-situ measurements
   - Provide web based access to results that flow from the project
2. Capacity Building to use these products for operational applications

Progress

- The base map for the generation of products for requested domains was prepared based on the inputs from participating IOGOOS countries
- Web based dissemination of near real-time satellite products viz. Chlorophyll-a, SST, kd_490, TSM to all requested countries was initiated on 1 November 2008
- In-situ measurements for the Indian region have been initiated as part of a National Project
- Plan for in-situ measurements for other participating countries has to be drawn up
- Generated remote sensing case studies for the following areas:
  Keystone Ecosystems – Tanzania, Malaysia;
  Shoreline Changes – Sri Lanka, Tanzania, Madagascar and Malaysia;
  ChloroGIN - Iran, Kenya, Maldives, Oman, Sri Lanka, Tanzania and Thailand;

Components of the Project

Operational Remote Sensing

- Near real time (NRT) processing of satellite derived Ocean Colour (OC) data
  - SST, Chl-a, Kd (490), TSM
- Web dissemination of satellite OC data products to Indian Ocean region at NRT
- Generation of value added products from satellite OC data (Fisheries, HAB, etc.)
- Preparation of Atlas of the OC Data Products

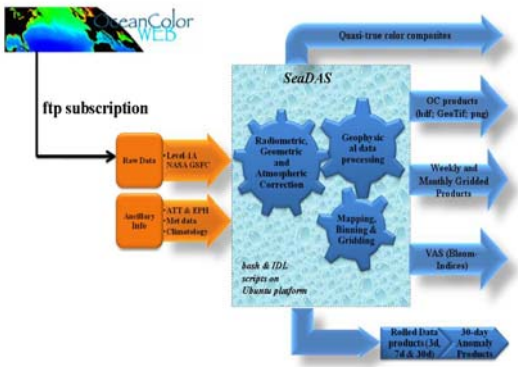
R & D Capacity Building

- To enhance potential applications of the satellite OC data
- Validation of existing ocean colour algorithms
- Algorithm Improvement/Development to retrieve ocean colour data products from satellite remote sensing.
- Preparation of Project Proposals for Donors

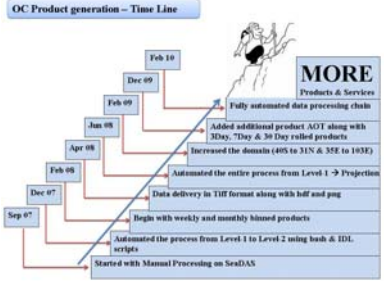
Insitu

Core Measurements: Chlorophyll-a (extracted fluorescence); Sea Surface Temperature; Coloured Dissolved Organic Matter (measured in a spectrophotometer, using10 cm pathlength,); Particulate absorption spectra; Suspended Sediment Concentration; Secchi Disk
Value-added measurements: Photosynthesis-irradiance experiments
Spectral reflectance measurements at the sea surface
Common measurement standards; Inter-comparison Exercises

MODIS – Aqua ADPC



OC Product generation – Time Line



MODIS – Aqua ADPC deliverables

Standard Products:
True Colour Composite, Chlorophyll_a, Kd_490, AOT869, CDOM_index, SST

Value Added Products (VAP)*:
TSM (Clark), Bloom Indices (Ahn and Shanmugham), 3-Days Rolled Composite, 7-Days Rolled Composite, 30-Days Rolled Composite, 30-Days Rolled Anomaly

Domain (40 S to 31 N & 35 E to 103 E):
India, Sri Lanka, Iran, Maldives, Oman, Tanzania & Thailand

Format:
HDF, PNG & TIFF

Resolution:
1 km & 4 km

Dissemination:** INCOIS website at Near real-time (NRT)

*Presently VAP are generated only for India-Sri Lanka domain
**The web-dissemination will resume once the new web page is ready

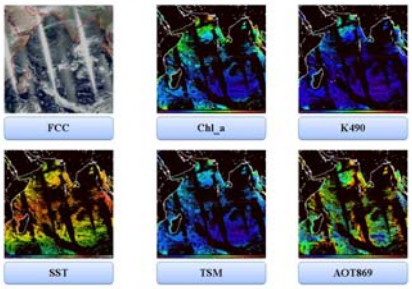
Dissemination Parameters

Sr. No.	Country	Domain	Focal Person	Resolution		
				Daily	Weekly	Monthly
1	Entire Domain	40°E to 31°N 35°E to 103°E		4 Km	4 Km	4 Km
2	India	04° N to 25° N 63° E to 93° E	Dr. T. Srinivasa Kumar, INCOIS	1 Km	4 Km	4 Km
	Sri Lanka	04° N to 25° N 63° E to 93° E	Dr Kamal Dharmasiri TENNAKOON, SARA, Sri Lanka Kantha Vaya, University of Ruhuna, Sri Lanka	1 Km	4 Km	4 Km
3	Tanzania	04° S to 11° S 39° E to 43° E	Dr Greg M WAGNER, University of Dar Es Salaam, Tanzania Dr. Margareth Kyewalyanga	1 Km	4 Km	4 Km
4	Maldives	02° S to 08° N 71° E to 75° E	Mr Ali Shareef National Meteorological Centre, Male, Maldives	1 Km	4 Km	4 Km
5	Kenya	02° S to 01° S 39° E to 43° E	Dr Johnson Kamanga Kenya Marine & Fisheries Research Institute, Mombasa, Kenya	1 Km	4 Km	4 Km
6	Iran	23° N to 25° N 47° E to 62° E	Dr Abbas Sofrabbi Executive Deputy of IRCO, Tehran	1 Km	4 Km	4 Km
7	Oman	16° N to 20° N 52° E to 62° E	Dr Y V B Sarma MIF CAMS Sultan, Qaboos University	1 Km	4 Km	4 Km
8	Thailand	1.7° N to 14° N 97° E to 103° E	Mr Somkiat Khokiattiwong Department of Marine and Coastal Resources, Phuket Marine Biological Centre, Phuket, Thailand	1 Km	4 Km	4 Km

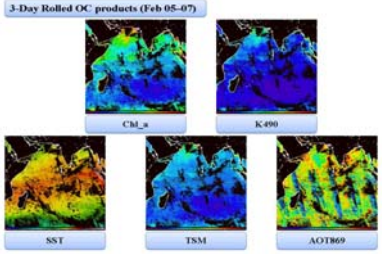
Data Products: Daily, 3-Day Rolled, 7-Day Rolled, 30-Days Rolled, weekly & monthly → Chl_a, K490, SST, TSM, AOT

Data Format: hdf, png & tiff

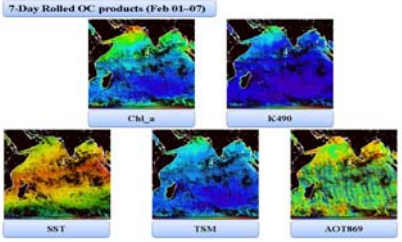
Daily OC Products (Feb 06)



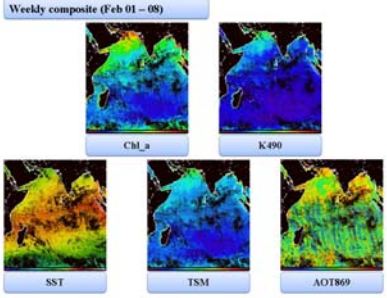
3-Day Rolled OC products (Feb 05–07)



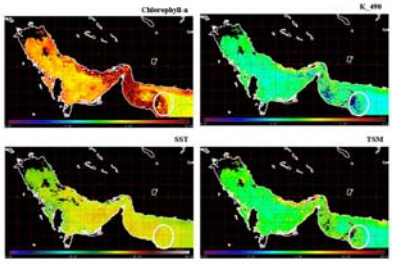
7-Day Rolled OC products (Feb 01–07)



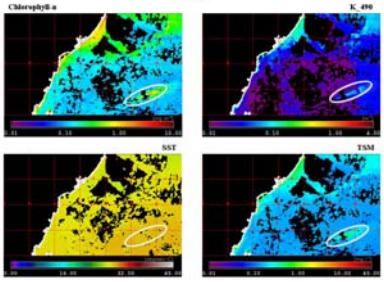
Weekly composite (Feb 01 – 08)



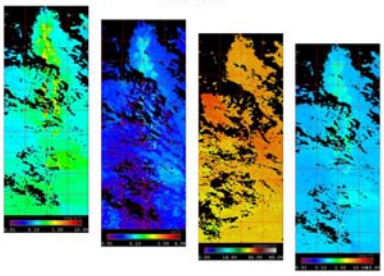
Iran



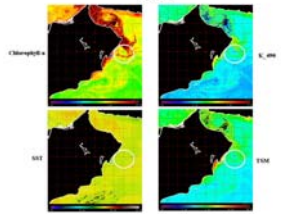
Kenya



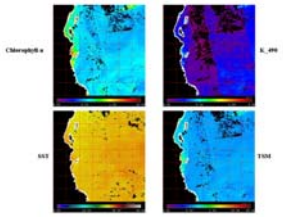
Maldives



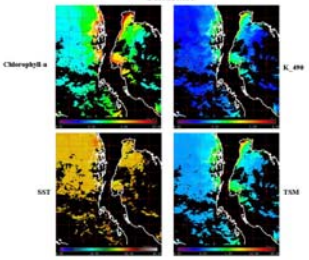
Oman



Tanzania



Thailand



Web Dissemination

The New Dissemination page will be released soon ....

In situ data Collection

A Sampling Strategy document was prepared including in situ sampling criterion, sampling positions, sampling period and relevant protocols for estimating chlorophyll, CDOM and TSM using Spectrophotometry, fluorometry and HPLC.

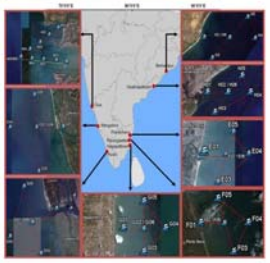
Ongoing sea campaigns as part of Cal/Val program and Inter-comparison Exercises

Five Hyperspectral Radiometers being used for the measurement of _in situ_ optical parameters.

Radiative transfer model HYDROLIGHT being used for the optical modeling of coastal waters.

Establishment of a centralized facility at CASMB, Annamalai University for in situ sample analysis using Spectrophometers, Fluorimeters, HPLC

Insitu measurements - India

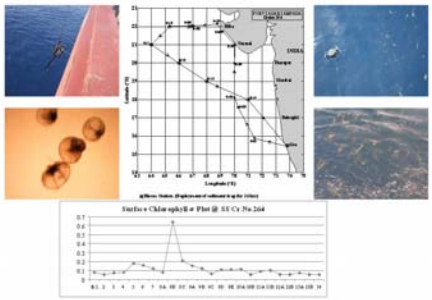


Goa	NIO
	Goa University
Mangalore	Mangalore University
Kochi	CIFT
Nagapattinam	CAS Marine Biology, Annamalai University
Parangipettai	
Pondicherry	
Visakhapatnam	Andhra University
Berhampur	Berhampur University

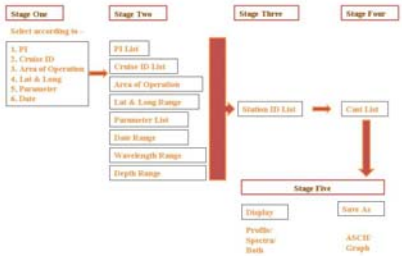
Sampling frequency	Monthly
Sampling parameters	Chlorophyll, SST, TSM, CDOM, DO & Nutrients
Instruments	Hyperspectral Radiometer, Spectrophotometer, Fluorometer
Common Measurement Standards; Inter-comparison Exercises	

ChloroGIN-IO is being executed through the Satellite Coastal and Oceanographic Research (SATCORE) project funded by Ministry of Earth Sciences (MoES), Govt. of India

Validation Campaign for BI



In situ data base

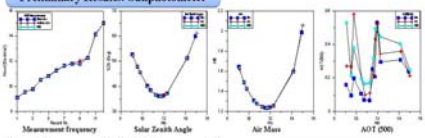


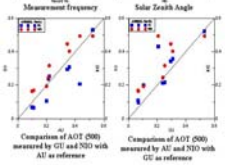
Intercomparison Exercises

Sr. No	Participating Agency	Instrument(s)
1	INCOIS	Satlantic HyperSpectral radiometer
2	NIO, Goa	Spectrophotometer, Sunphotometer, GPS, Fluorometer, HPLC
3	Goa University	Spectrophotometer, Sunphotometer, GPS
4	Mangalore University	Spectrophotometer
5	CIFT, Kochi	Spectrophotometer
6	Annamalai University	Spectrophotometer, fluorometer, HPLC
7	Andhra University	Spectrophotometer, Sunphotometer, GPS
8	Berhampur University	Spectrophotometer
9	NIO-RC, Visakhapatnam	Spectrophotometer, fluorometer, HPLC

- The exercise was carried out at Visakhapatnam, east cost of India on November 12th & 14th, 2009
- The sampling was performed simultaneously onboard two vessels, CRV Sagar Paschimi and Janakiraman
- On November 12, 2009, both the vessels were parked at 50m depth at a distance of 15 km from the coast
- On November 14, 2009, both the vessels were be parked at 30m depth at a distance of 10 km from the coast
- Three sunphotometers were operated simultaneously from 0900 to 1600 hrs with an interval of 15 min
- Four hyperspectral radiometers were operated simultaneously
- Total 10 sets of water samples were collected in duplicate. Nine sets were transported, in liquid nitrogen containers, to individual PIs for the analysis. One set was analyzed at NIO-RC, Visakhapatnam at the earliest

Inter-comparison Exercises
Preliminary Results: Sunphotometer





	440	500	673	870
NIO	0.90	0.91	0.87	0.85
GU	0.71	0.73	0.70	0.67

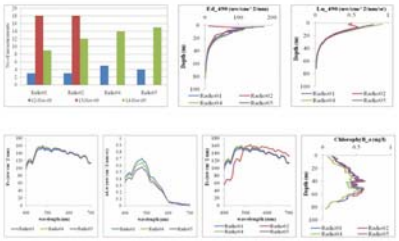
Inter-comparison with data of AU as reference (R^2)

	440	500	673	870
NIO	0.65	0.63	0.63	0.64
AU	0.71	0.73	0.70	0.67

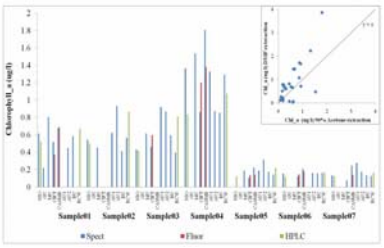
Inter-comparison with data of GU as reference (R^2)

Though the data was sparse to arrive at any definite conclusion, there were all closely matched and correlated well.

Inter-comparison Exercises Preliminary Results: Radiometer



Inter-comparison Exercises Preliminary : Water Sample



Capacity Building

- "Bid-writing workshop for IOGOOS and SEAGOOS regions" held at Kota Kinabalu, Sabah, Malaysia, during December 10 – 14, 2008
  - Three draft project proposals have been made for the IOGOOS Coastal Projects. The Project titles are (i) Ecosystems and Resource Management, (ii) Shoreline change and impact of climate change and (iii) Chlorophyll Mapping for resource management
- "COASTMAP-IO Workshop on drafting project proposals to International Financial Institutions" held at INCOIS, Hyderabad during November 04 – 07, 2009
  - 17 Participants from 11 Countries + 02 facilitators
  - India, Kenya, Madagascar, Maldives, Mauritius, Mozambique, Tanzania and Thailand.
- "SAFARI International Symposium on Remote Sensing and Fisheries" as well as ChloroGIN Workshop held at Kochi, India during February 15 – 19, 2010
  - 51 participants from 20 countries participated
  - Progress on six ChloroGIN Nodes (ChloroGIN -Europe, ChloroGIN – Indian Ocean, ChloroGIN - Antarctic, ChloroGIN - Africa, ChloroGIN - Canada, ChloroGIN - Asia as well as Global ChloroGIN has been made.
  - There was a general consensus that ChloroGIN-Indian Ocean has advanced impressively over the past two years, and that they have addressed most of the components of ChloroGIN. The difference with the other nodes is related to the availability of resources.
  - ChloroGIN-Indian Ocean could be a model for the other nodes.
  - Submission of a Proposal to GEO
- Training to Malaysia (Nov 2009), AMESD (June 2009) , Oman (TBD)

Contents of the Proposal

The ChloroGIN network represented at the meeting agreed to submit a proposal. Proposed elements included:

1.Establishment and development of *in situ time series stations in waters around Latin America* and in the Indian Ocean rim countries. (Iran, Kenya, Maldives, Oman, Tanzania, Thailand, Mauritius and Sri Lanka.)

Requirements include:

1)human resources;
2)instrumentation to carry out the minimum core measurements;
3)instrumentation to carry out important determinations for the estimation of ecological indicators (primary production, biodiversity);
4)workshops to inter-compare methods to develop the best protocols for the variables involved.

2. Extension of ChloroGIN Southeast Asia.
3. Improvement of data dissemination in a timely fashion in member countries of ChloroGIN, especially through the internet.
4. International symposium on the benefits of Earth Observations for Fisheries and Aquaculture.
5. Workshops and outreach to policy makers and the user community.
6. A global set of synoptic, calibrated, consistent satellite data for ecosystem studies in coastal waters of developing countries.
7. Establishment of an International Secretariat for ChloroGIN to improve promotion and coordination of activities.

Outcome of ChloroGIN Meeting

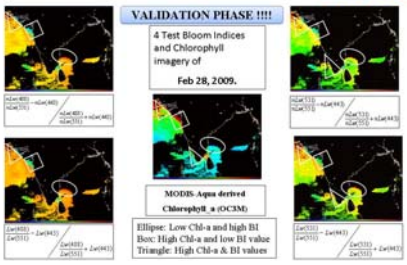
New Products – Indicators

In addition to geophysical products such as SST, chlorophyll, diffuse attenuation coefficient at 490 nm (Kd490) at daily, weekly and monthly time scales, it was important to give priority to indicators that are easy to understand and use by the whole community including decision makers. Some important indicators were identified:

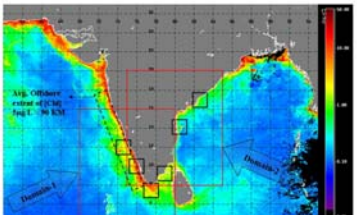
- Bloom indicators - timing and magnitude of bloom – (e.g. case study in the N. Atlantic Platt & Sathyendranath 2008 methodology)
- Frontal zone – mesoscale features
- PFZs (Potential Fishing Zones); identification of mesoscale features
- PFTs (Phytoplankton functional types) such as Trichodesmium, coccolithophores, diatoms – e.g. INCOIS making RTI (Red Tide Index) for HABs (Harmful Algal Blooms) as a first step and HAB index in South Africa
- Water quality related indicators (eutrophication index, water transparency) case study in Europe (Oxyrisk)
- Primary Production estimates
- Regional Chl and SST anomalies (implies long satellite data time series)

VAS 01 → BLOOM INDICES (BI)

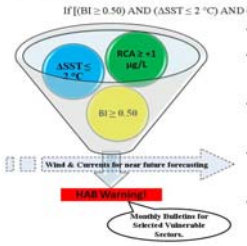
INCOIS



HABS warning – Areas to be monitored

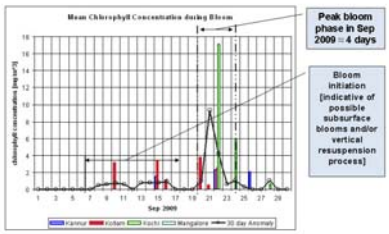


Conceptual framework & implementation:

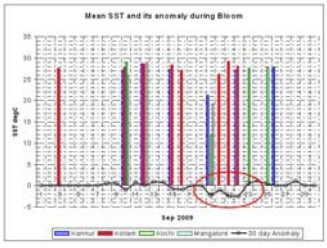


- Data pulling from a linear stack of L3 data.
- Anomaly in Chlorophyll and SST are computed using 35-5d → 5 day lag, over a 30-day mean.
- Presently, data in each HDF is queried using 5x5 box *out_track* utility in SeaDAS.
- A GDAL wrapper version is being tested for faster querying at a pixel location without opening the file.
- Integration into a Decision System <update *MotherOfAll.bash*>.

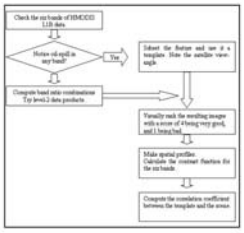
Preliminary results

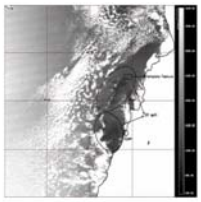


Temporal Characteristics of Sep 2009 Bloom Event



VAS 02 → Oil spill detection





Lotliker, A. A. Mupparthy, R. S., Tummala, S. K., Nayak, S. R. Evaluation of high resolution MODIS-Aqua data for oil spill monitoring. Proc. SPIE, Vol. 7150, 71500S (2008); DOI:10.1117/12.804907

What next !!!!

- Continue providing products to the IO member Institutions
- Development of new products / indicators
- Capacity Building of the participating member institutions to undertake time series measurements for core variables
  - Training
  - Methodology Document
  - Funding (Proposal??)

- Capacity Building Opportunities
  - EC-JRC training course on 'Methods and Applications of Ocean Colour remote sensing in coastal and regional seas' during 2011 in Mauritius
  - NF-POGO regional training course on 'Ocean Colour Remote Sensing" during 2012 at INCOIS, Hyderabad

Proposed activities

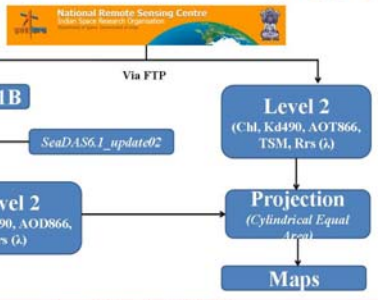
- ✓ Monitoring and improvement of ADPC
- ✓ Development of an early warning system for detection of HABS using satellite data
- ✓ Ecosystem Modeling for short term fisheries forecast
- ✓ Maintenance of *in situ* bio-optical database and quality check of data
- ✓ Developing maps of biological fronts and analysis of feature persistence
- ✓ Primary productivity modeling - generation of PI parameters
- ✓ Exploring possibilities of using MERIS high resolution ocean colour data products in understanding coastal dynamics

Progress so far ....

Task: - Monitoring and improvement of ADPC

- ✓ The MODIS – Aqua Automatic Data Processing Chain (ADPC) has been re-designed and improved with new logic.
- ✓ The five new that products have been included are AOD869, three days rolled products, seven days rolled product, 30 days rolled products and Quasi-True Color Browse imagery (FCC) for all domains.
- ✓ Two value added products such as Bloom Indices and TSM has been added in ADPC
- ✓ The data mask of optical products has been applied to SST data at L2 level.
- ✓ The data products were generated at 1 km and 4 km spatial resolution.
- ✓ OCM-2 data processing chain has been set up

OCM-2 ADPC

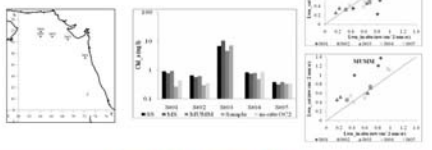


Advisory Services and Satellite Oceanography Group

Ocean Colour Application Team

Validation of satellite derived OC products

- ✓ Out of the total profiles five match up points were available, following criteria of Bailey and Werdell (2006), for validation with MODIS – Aqua data.
- ✓ The match up was performed by varying three different atmospheric correction models. The evaluation was done at 1) atmospheric level by analyzing aerosol radiance, 2) radiance level by comparing normalized water leaving radiance and 3) product level by comparing chlorophyll-a concentration.
- ✓ The OCM empirical algorithm was used to retrieve chlorophyll-a concentrations from the satellite image.

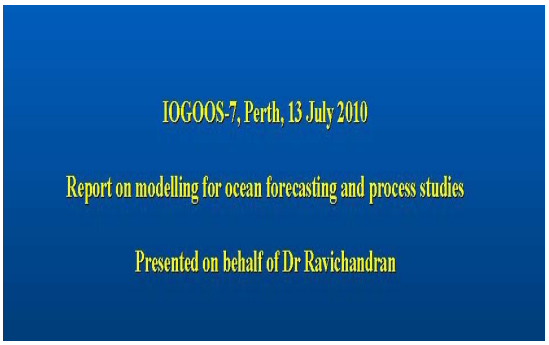


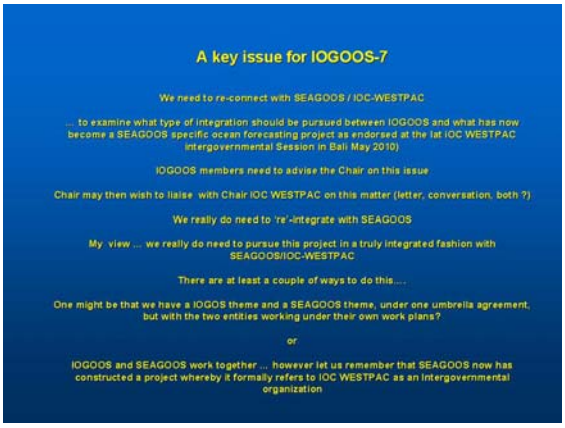
Advisory Services and Satellite Oceanography Group

Ocean Colour Application Team

Annexure-21

Report on Modelling for Ocean Forecasting & Process Studies by Dr. Nick D' Adamo





A good example of programmatic integration is Bluelink
(BoM, CSIRO, RAN)

Web-based 7-day forecasts of the *'underwater weather'*

for Australia's EEZ and beyond

MODELS, PREDICTIONS
http://www.bom.gov.au/oceanography/forecasts

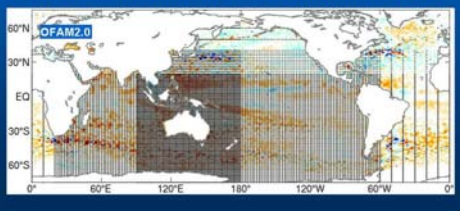
Click on the region of interest
Obtain 7-day forecast – T, S, currents

BLUELINK

Hydrodynamic model → global output

assimilating
Global data from the Global Ocean Observing System (GOOS)

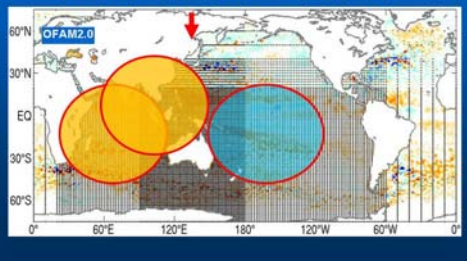
To give finer resolution answers near Australia and potentially beyond



Facilitating the regional APPLICATION of Bluelink

SEAGOOS + IOGOOS + PIGOOS

SEAGOOS related plans being developed (incl. Malaysia)



Annexure-22

Ocean Forecasting Demonstration Project for IOGOOS & SEAGOOS

Project plan, as an output of the:

Project Planning Meeting, 9-10 July 2010 & Report on the Working Group Meeting 13-14 July 2010 Perth, Western Australia.

Project Title:		
Principal investigators:		
Collaborative partners:	**Start date:**	**Finish date:**
Project Sponsors		

1. Project Description:

(Summary of project: *what*, *how*, *why*, *where* etc. What has led to the project being conceived in terms of the interests of IOGOOS, SEAGOOS, IOC, BLUElink> Australia and also in terms of the specific sub-regional demonstration areas within IOGOOS and SEAGOOS, respectively. Link to the requirements of the respective stakeholders in terms of the outcomes that are to be achieved. Should be useful for publicity purposes (eg in forming the basis for a press release or funding applications)

Include in here or at an appropriate point in this document a good overview of the generic (relevant to all partners) societal drivers, in terms of the users. Design these statements by adopting a bottom up approach ….. consult the end users → express their societal drivers → results in the tools / capacities needed in terms of ocean forecasting / downscale models / data requirements (eg ocean observations), and process understanding → guides the technical groups inherent in the project an guides the development of the 'specific geographically idiosyncratic objectives' for each of the demonstration sub-regions of this project. NB here the Indian case study (explicit user consultations preceded their own ocean scale model development – Srinivas to provide an over view of what they did).

2. Project Objectives (Generic objectives and then specific objectives and for each sub-regional demonstration area).

(What we hope to achieve)

The regions:

Ocean Scale

South West IO (focused on Mauritius)

North ~~Central~~ IO (focused on India)

Central SEA (focused on southern South China Sea, including Malaysian, Gulf of Thailand and Indonesian regions)

South-East IO (focused on the Arafura – Timor Sea region)

????? other areas

…. Improved quality of regional/global scale modeling capacities through:

- **Validation and inter-comparison of global and basin sale models in the IO-SEA-WP regions, noting the domains of the various ocean forecasting models in question (eg China's, India's Australia'…)**
- **NB China's model covers the NIWP from 30E to 150E and 20S to 50N. Horizontal grid res 1/8th deg.**
- **NB India's model currently covers (could be extended, to be advised) the 30E to 120E and 20S to 30N. Horizontal grid res 1/4 deg.**
- **NB Australia's model (ie the forthcoming version of BLUElink) covers 75S to 75N and full E-W global extent. Horiz grid 1/10th deg.**
- **European model (MERCATOR & FOAM, two key models for the European ocean forecasting community).**
- **USA – the HYCOM model.**
- **Other relevant models ?? to be investigated.**

South West IO (focused on Mauritius)

North ~~Central~~ IO (focused on India)

Specific objectives for this demo area.

- **Develop a framework and program for exchange of technical expertise in ocean modeling and ocean forecasting**
- **Inter-comparison of model and ocean forecasting products (eg forcing fields for model runs and the results of model runs) (computer outputs), particularly to examine relative utilities for site specific applications in the demo area, with these inter-comparisons undertaken at all possible scales 9borad scale and scales relevant to fine scale nesting).**
- **Assessment of the utility of available regional models as providers of boundary conditions for nested finer scale models for site specific modeling in the demo area**
- **Capacity Development (including training) in: numerical ocean modeling, data assimilation, ocean observations (both for the collection of data, and data analysis thereof). In this context, develop a program of inter-action between key scientists in this sub demo project areas and neighboring related ocean observing and ocean forecasting projects (eg Australian IMOS, www.imos.org.au; IndOOS, the respective Chinese and Indian observation program etc).**

Central SEA (focused on southern South China Sea, including Malaysian, Gulf of Thailand and Indonesian regions)

Specific objectives for this demonstration area. To be edited by Nur and colleagues…

- **Develop and apply an operational forecasting system for *ecological and economic and social* objectives. Current known priorities include oil/gas, fisheries. (this will be further detailed at the imminent workshop for the SEAGOOS / IOC WESTPAC ocean forecasting project).**
- **Through this development, use the tools inherent within the system to gain an improved understanding of key oceanographic processes, as relevant to societal needs.**
- **A tailored ocean observing system (in-air (eg satellite) and in-water (eg moorings) 'science plan', related 'implementation program' and a related 'data management framework, to service the modeling and ocean forecasting needs of this demo area (to provide information both for model selection, model application, model validation, ocean forecasting). This should include the concept and implementation of joint cruises (bringing together the potential operational ocean observing resources of the principal partners in this project.**
- **Capacity Development (including training and demonstration project work) in: numerical ocean modeling, data assimilation, ocean observations (both for the collection of data, and data analysis thereof), associated IT / data management (ref: eg Malaysia's developing national ocean data centre). In this context, develop a program of inter-action between key scientists in this sub demo project area and neighboring related ocean observing and ocean forecasting projects (eg Australian IMOS, www.imos.org.au; IndOOS, the respective Chinese and Indian observation program etc).).**
- **Identification and consolidation of existing useful regional data for this project and data management thereof. This includes the development of relationships to gain access to associated data streams where possible, in relation to current ocean observing programs in the area.**

South-East IO (focused on the Arafura – Timor Sea region)

- **Develop required boundary condition forcings for modeling in this region (particularly re the PIT – Pacific Indonesian Throughflow), with particular reference to environmental 'planning' and 'management' for industry stakeholders (eg oil, gas, including associated maritime transport, fisheries) (and by association, biodiversity conservation and environmental planning/management (eg spill response and management stakeholders).**
- **Demonstration - fine scale modeling provided for by these boundary conditions (eg Scott Reef area)**
- **Associated transport modeling for key parameters eg oil, sediment…**
- **Ascertain minimum data requirements to achieve required levels of accuracy from the modeling.**
- **For advocacy purposes to the key stakeholders (users, beneficiaries of this demo project) – a document that summaries the project (limit to 1 page Exec Sum and 10 pages of body)**

OVER-ARCHING OBJECTIVE - Generic Capacity Development in the application and use of ocean scale forecasting models in sub-regional areas of IO and SEA GOOS, through:

CORE Objectives

- **Capacity Building / Training in ocean forecasting (includes modeling, data assimilation, quality control of data, and IT generally, establishing a forum amongst partners for ocean forecasting)**
    - **Unlocking validation data sets for the mutual benefit of all project stakeholders**
    - **Model inter-comparisons (at all relevant scales, including regional to local scale)**

CROSS-CUTTING OBJECTIVES:

- **Process understanding (involves general research on oceanographic processes)**
- **Building a stronger constituency and advocacy for the project's overall mission (eg demonstrations, visualisations, animations for specific regional/local systems of interest to project partners) … note Ray Steedman's comments here.**

3. Methodology (Generic methods and then specific methods for each sub-regional demonstration area).

(Details of how we propose to do the project, use appendices if necessary)

List and brief description of the methods (*provide the steps required in order to undertake the project*)

Ocean Scale

…. Improved quality of regional/global scale modeling capacities through:

- **Validation and inter-comparison of global and basin sale models in the IO-SEA-WP regions, noting the domains of the various ocean forecasting models in question (eg China's, India's Australia'…)**

  A work plan needs to be developed and implemented to:

  Identify the metrics needed in order to collate the related data required for this task by circulating the relevant, most up to date, GODAE metrics document to the project group focal points: at this stage yourself.

  Collate the relevant data required for this task.

  Undertake the inter-comparisons of observed metrics to the model's metrics to assess the models' performances.

- **NB China's model covers the NIWP from 30E to 150E and 20S to 50N. Horizontal grid res 1/8th deg.**

- **NB India's model currently covers (could be extended, to be advised) the 30E to 120E and 20S to 30N. Horizontal grid res 1/4 deg.**
- **NB Australia's model (ie the forthcoming version of BLUElink) covers 75S to 75N and full E-W global extent. Horiz grid 1/10th deg.**

South West IO

North IO

- **Develop and apply an operational forecasting system for socio-economic and ecological objectives. Current known priorities include oil/gas, fisheries, shipping.**

- **Through this development, use the tools inherent within the system to gain an improved understanding of key oceanographic processes, as relevant to societal needs.**

- **A tailored ocean observing system (in-air (eg satellite) and in-water (eg moorings) 'science plan', related 'implementation program' and a related 'data management framework (including computational infrastructure), to service the downscaled modeling and ocean forecasting needs of this demo area (to provide information both for model selection, model application, model validation, ocean forecasting). This should include the concept and implementation of joint cruises (bringing together the potential operational ocean observing resources of the principal partners in this project.**

- **Capacity Development (including training and demonstration project work) in: numerical ocean modeling, data assimilation, ocean observations (both for the collection of data, and data analysis thereof), associated IT / data management. In this context, develop a program of inter-action between key scientists in this sub demo project area and neighboring related ocean observing and ocean forecasting projects (eg IndOOS, the respective Chinese and Indian observation program etc).**

- **Identification and consolidation of existing useful regional data for this project and data management thereof. This includes the development of relationships to gain access to associated data streams where possible, in relation to current ocean observing programs in the area.**

Undertake an analysis of user priorities for this project.

Undertake a CD needs/gap assessment (document it) and include as part of that development, demonstration project work. (For this, at least assess: expertise in numerical ocean modeling, data assimilation, ocean observations (both for the collection of data, and data analysis thereof), associated IT / data management).

Key points for this:
Numerical ocean modeling: consult the ROMS group for their possible role and input to this.

Data assimilation: consult the NOAA group (GODAS System) for their possible role and input to this; ditto – consult BLUElink>.

Develop an ocean observing system (in-air (eg satellite) and in-water (for both hydrodynamic sub-surface and atmospheric surface parameters) (eg moorings) 'science plan', related 'implementation program' plan and a related 'data management framework (including computational infrastructure), focusing in the first instance on: data needed to begin validating the downscaled models.

Develop a collaborative proposal for inter-action between key scientists in this sub demo project area and neighboring related ocean observing and ocean forecasting projects.

Because in the NIO region, the development and application of an operational forecasting system for socio-economic and ecological objectives may be some time away (e.g. Bangladesh, Maldives, Myanmar, Sri Lanka), hence at this point in time the key need would be to develop a strategic plan for this objective, albeit brief. This will be strategically important to assist in this objective at the appropriate time. The strategic plan should be written with due understanding and review of the history of development of existing ocean forecasting systems from around the world.

SE IO

Method section to be provided out of session… Ray/Nick.

Central SEA

- **Develop and apply an operational forecasting system for socio-ecological objectives. Current known priorities include oil/gas. (this will be further detailed at the imminent workshop for the SEAGOOS / IOC WESTPAC ocean forecasting project).**
- **Through this development, use the tools inherent within the system to gain an improved understanding of key oceanographic processes, as relevant to societal needs.**
- **A tailored ocean observing system (in-air (eg satellite) and in-water (eg moorings) 'science plan', related 'implementation program' and a related 'data management framework (including compututational infrastructure), to service the downscaled modeling and ocean forecasting needs of this demo area (to provide information both for model selection, model application, model validation, ocean forecasting). This should include the concept and implementation of joint cruises (bringing together the potential operational ocean observing resources of the principal partners in this project.**
- **Capacity Development (including training and demonstration project work) in: numerical ocean modeling, data assimilation, ocean observations (both for the collection of data, and data analysis thereof), associated IT / data management (ref: eg Malaysia's developing national ocean data centre). In this context, develop a program of inter-action between key scientists in this sub demo project area and**

neighboring related ocean observing and ocean forecasting projects (eg Australian IMOS, www.imos.org.au; IndOOS, the respective Chinese and Indian observation program etc).

- **Identification and consolidation of existing useful regional data for this project and data management thereof. This includes the development of relationships to gain access to associated data streams where possible, in relation to current ocean observing programs in the area.**

Undertake an analysis of user priorities for this project.

Undertake a CD needs/gap assessment (document it) and include as part of that development, demonstration project work. (For this, at least assess: expertise in numerical ocean modeling, data assimilation, ocean observations (both for the collection of data, and data analysis thereof), associated IT / data management).

Key points for this:
Numerical ocean modeling: consult the ROMS group for their possible role and input to this; ditto – consult HYCOM/NERC; ditto – consult relevant groups for POM.
Data assimilation: consult the NOAA group (GODAS System) for their possible role and input to this; ditto – consult BLUElink>.

Develop an ocean observing system (in-air (eg satellite) and in-water (for both hydrodynamic sub-surface and atmospheric surface parameters) (eg moorings) 'science plan', related 'implementation program' plan and a related 'data management framework (including computational infrastructure), focusing in the first instance on: data needed to begin validating the downscaled models.

Develop a collaborative proposal for inter-action between key scientists in this sub demo project area and neighboring related ocean observing and ocean forecasting projects.

For Malaysia at least: prepare a proposal for the identification and consolidation of existing useful regional data for this project and data management thereof and build relationships for this purpose, and submit this to the relevant Government agency or Ministerial portfolio (ie MOSTI) for consideration.

For Thailand at least: …. DMCR holds a substantial data set relevant to this objective and PMBC has the role of identifying which of these data is relevant to this project; and then of consolidating the data into a form that is of use.

Because in the SEA region, the development and application of an operational forecasting system for socio-ecological objectives may be some time away, hence at this point in time the key need would be to develop a strategic plan for this objective, albeit brief. This will be strategically important to assist in this objective at the appropriate time. The strategic plan should be written with due understanding and review of the history of development of existing ocean forecasting systems from around the world.

4. Expected Outcomes:

(When completed, how will this project have made a direct contribution to the issues being addressed, ie towards better tactical or strategic management of the region question)

South West IO

North-Central IO

Central SEA

5. Outputs: (What ***products*** will be produced: eg data, data reports, maps, posters, technical reports, scientific papers, thesis etc).	**Timing:** (ie by what date)
South West IO **North-Central IO** **Central SEA**	

6. Linkage to relevant regional plans:

(Specify which strategies in relevant regional; plans this project addresses).

South West IO

North-Central IO

Central SEA

7. Resource requirements:

(Overall details of cash requirements and/or commitments and/or in-kind contributions for each sub-regional demonstration area. This section serves to clearly specify what is needed to undertake the project in terms of the true resources needed for the project, with all contributions considered.)

Central SEA

Undertake an analysis of user priorities for this project.

FTEs (Full Time Equivalents) (ie No. of person years)
Malaysia 0.5
Thailand 0.25

Operational cash TBA

Timeframe to do this
Malaysia 0.5
Thailand 0.5

Undertake a CD needs/gap assessment (document it) and include ocean forecasting demonstration work. (For this, at least assess: expertise in numerical ocean modeling, data management (including computational infrastructure), ocean observations (both for the collection of data, and data analysis thereof), associated IT / data management).
Key points for this:
Numerical ocean modeling: consult the ROMS group for their possible role and input to this; ditto – consult HYCOM/NERC; ditto – consult relevant groups for POM.
Data assimilation: consult the NOAA group (GODAS System) for their possible role and input to this; ditto – consult BLUElink>.

Footnote – this would include running ocean forecasting systems in demonstration mode…

FTEs (Full Time Equivalents) (ie No. of person years)
Malaysia 0.25 + 10 students + 5 scientists + 5 technicians
Thailand 0.25 + 5 students + 5 scientists + 5 technicians

Operational cash TBA

Timeframe to do this
Malaysia 0.25 + 3 years
Thailand 1.0 + 3 years

Develop an ocean observing system (in-air (eg satellite) and in-water (for both hydrodynamic sub-surface and atmospheric surface parameters) (eg moorings) 'science plan', related 'implementation program' plan and a related 'data management framework' (including computational infrastructure), focusing in the first instance on: data needed to begin validating the downscaled models.

FTEs (Full Time Equivalents) (ie No. of person years)
Malaysia 3
Thailand 3

Operational cash TBA

Timeframe to do this
Malaysia 2
Thailand 2

Develop a collaborative proposal for inter-action between key scientists in this sub demo project area and neighboring related ocean observing and ocean forecasting projects.

FTEs (Full Time Equivalents) (ie No. of person years)
Malaysia 0.5
Thailand 0.5

Operational cash TBA

Timeframe to do this
Malaysia 0.5
Thailand 0.5

For Malaysia at least: prepare a proposal for the identification and consolidation of existing useful regional data for this project and data management thereof and build relationships for this purpose, and submit this to the relevant Government agency or Ministerial portfolio (ie MOSTI) for consideration.

For Thailand at least: …. DMCR holds a substantial data set relevant to this objective and PMBC has the role of identifying which of these data is relevant to this project; and then of consolidating the data into a form that is of use.

FTEs (Full Time Equivalents) (ie No. of person years)
Malaysia 0.5
Thailand 0.5

Operational cash TBA

Timeframe to do this
Malaysia 0.5
Thailand 0.5

Because in the SEA region, the development and application of an operational forecasting system for socio-ecological objectives may be some time away, hence at this point in time the key need would be to develop a strategic plan for this objective, albeit brief. This will be strategically important to assist in this objective at the appropriate time. The strategic plan should be written with due understanding and review of the history of development of existing ocean forecasting systems from around the world.

FTEs (Full Time Equivalents) (ie No. of person years)
Malaysia 1.5
Thailand 1.5

Operational cash TBA

Timeframe to do this
Malaysia 1
Thailand 1

Sum= xxx FTEs

Footnote: estimate of resources needed for computational infrastructure(hardware)
= 500k (USD)

Northern Indian Ocean

Undertake an analysis of user priorities for this project.

FTEs (Full Time Equivalents) (ie No. of person years)
India 0.5
Myanmar 0.5
Sri Lanka
Bangladesh
Maldives

Operational cash TBA

Timeframe to do this (years)
India 0.5
Myanmar 0.5
Sri Lanka
Bangladesh
Maldives

Undertake a CD needs/gap assessment (document it) and include ocean forecasting demonstration work. (For this, at least assess: expertise in numerical ocean modeling, data management (including computational infrastructure), ocean observations (both for the collection of data, and data analysis thereof), associated IT / data management).
Key points for this:
Numerical ocean modeling: consult the ROMS group for their possible role and input to this.
Data assimilation: consult the NOAA group (GODAS System) for their possible role and input to this; ditto – consult BLUElink>.

Footnote – this would include running ocean forecasting systems in demonstration mode…

FTEs (Full Time Equivalents) (ie No. of person years)
India 0.25 + 10 students + 5 scientists + 5 technicians
Myanmar 0.25 + 5 students + 3 scientists + 3 technicians
Sri Lanka
Bangladesh
Maldives

Operational cash TBA

Timeframe to do this
India 0.25 * 3 years
Myanmar 0.25 * 3 years
Sri Lanka
Bangladesh
Maldives

Develop an ocean observing system (in-air (eg satellite) and in-water (for both hydrodynamic sub-surface and atmospheric surface parameters) (eg moorings) 'science plan', related 'implementation program' plan and a related 'data management framework' (including computational infrastructure), focusing in the first instance on: data needed to begin validating the downscaled models.

FTEs (Full Time Equivalents) (ie No. of person years)
India 2.0
Myanmar 2.0
Sri Lanka
Bangladesh
Maldives

Operational cash TBA

Timeframe to do this
India 1
Myanmar 0.5
Sri Lanka
Bangladesh
Maldives

Develop a collaborative proposal for inter-action between key scientists in this sub demo project area and neighboring related ocean observing and ocean forecasting projects.

FTEs (Full Time Equivalents) (ie No. of person years)
India 0.5
Myanmar 0.5
Sri Lanka
Bangladesh
Maldives

Operational cash TBA

Timeframe to do this
India 0.5
Myanmar 0.5
Sri Lanka
Bangladesh
Maldives

Because in the NIO region, the development and application of an operational forecasting system for socio-economic and ecological objectives may be some time away, hence at this point in time the key need would be to develop a strategic plan for this objective, albeit brief. This will

be strategically important to assist in this objective at the appropriate time. The strategic plan should be written with due understanding and review of the history of development of existing ocean forecasting systems from around the world.

FTEs (Full Time Equivalents) (ie No. of person years)
India 1.0
Myanmar 1.0
Sri Lanka
Bangladesh
Maldives

Operational cash TBA

Timeframe to do this
India 1.0
Myanmar 1.0
Sri Lanka
Bangladesh
Maldives

Sum= xxx FTEs

Footnote: estimate of resources needed for computational infrastructure(hardware) = 500k (USD) per country:
India: existing resources
Myanmar: yes
Sri Lanka
Bangladesh
Maldives

1	**Project Budget** (indicative)						**Out Years Budget** (if applicable - ie if the project is to longer than 1 year)		
							Yr 2	**Yr 3**	**Yr 4 etc**
							$	**$**	**$**
TOTAL									

8. Project Workplan:
Task by task for each sub-regional demonstration area.

Task							

9. Summary of source and amount of funds and in-kind resources:
Source 1:
Source 2:
etc

10. Deliverables:
(What will we deliver and when in terms of tangible products in respect to achieving the objectives)

Deliverable 1 and time of delivery;

Deliverable 2 and time of delivery:

etc

11. Communication Plan:
(How you plan to communicate the progress and results of the project to the wider community)

12. Data Management:
(where will the data be stored, in what form, metadata, backups etc.

13. Notes
(any other general comments)

Way forward, including:

- **Identification of any key issues, constraints, opportunities;**

Have a draft of this workshop report ready for review by 1st week of August, in time for the SEAGOOS ocean forecasting demonstration project workshop (third quarter of 2010).

Finalise the report in time for the next IOGOOS and WESTPAC meetings (IOGOOS will be either early or mid 2011) WESTPAC sci meeting will be in May 2011 in Sth Korea.

- **Key actions by delegates for sub-regional demonstration areas;**

Review the draft workshop report, after I send it out in a few weeks.

- **Identification of strategies to obtain funding/resources; and**
- **Next workshop objectives**

- **Next workshop – date, venue, host …..**

We don't really know yet when and for what specific objectives this workshop is needed….although we would want to finalise on an agreed project plan by and for that meeting

We probably need to wait on the outcomes of the SEAGOOS ocean forecasting demonstration project workshop (third quarter of 2010).

But if there is a need to meet again, it would have to be either Dec 2010 or Jan/Feb 2011. As an aside, note that IOCINDIO may be meeting in Dec 2010 (in Doha, Qatar).

Where?

Host?

End?????????

Annexure -23

Progress of Keystone project on Monitoring Shoreline Change

Monitoring of Shoreline Change

Tennakoon T.K.D, Nagaraja Kumar M, Jinadasa S.U.P,

Progress since IOGOOS VI

- Drafting of Project Proposals for 03 sub-projects of Indian Ocean Core Remote Sensing Project
- Case Studies by member countries of the project

Participating Countries

- Bangladesh
- India
- Malaysia
- Seychelles
- Sri Lanka
- Thailand
- Tanzanaia

Proposed Plan during 2009-10

- **Build up a project proposal (further through the workshop or correspondence) for the next IOGOOS meeting and submit to the Donor Agencies. It is expected that IOC will help the event (to identify expert etc, If workshop need Sri-Lanka would like to host it)**
- **It was agreed to do case studies among group member's countries as a initial step and result to be present to next IOGOOS VII meeting**

Case Studies

- Case studies have been conducted only by
  - India
  - Sri Lanka
  - Tanzania
  - Thailand

Case Studies - India

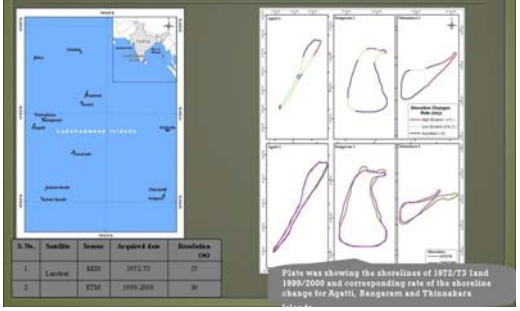
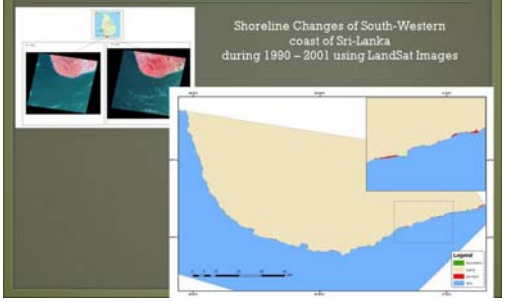


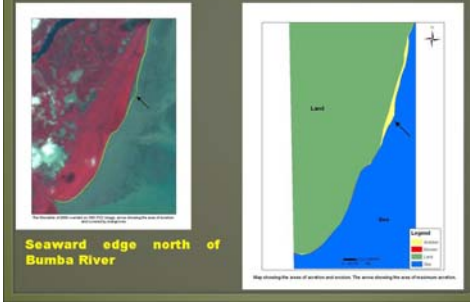
Plate was showing the shorelines of 1972/73 land 1999/2000 and corresponding rate of the shoreline change for Agatti, Bangaram and Thinnakara

Case Study – Sri Lanka



Shoreline Changes of South-Western coast of Sri-Lanka during 1990 – 2001 using LandSat Images

Case Study - Tanzania



Seaward edge north of Bumba River

Case Study - Thailand

Constrains

- National focal points
- Most of present focal points of the project due to unknown reasons weak in correspondence
- Therefore it is necessary to review national focal points. Membership can assist to find active focal points

Aspirations / Goals

- It is necessary the project proposal to reinforce further. Expecting IOC will assist on this matter. May be by correspondence or through workshop, once new focal points been identified. Sri-Lanka would like to host such event
- Funding Agency – It would grateful if IOC or regional alliance like BOBLME looking to this matter

Annexure-24

Indian Ocean Core Remote Sensing Project – Working Group -2 Report

Indian Ocean Core Remote Sensing Project

Working Group 2 of IOGOOS

WG2 Participants (Indian Ocean Core Remote Sensing Project)

- Bangladesh [Mohammad Zahedur R. Chowdhury (zahedims@yahoo.com)]
- BOBLME [Rudolf Hermes (rudolf.hermes@fao.org)]
- India [T. Srinivasa Kumar (srinivas@incois.gov.in); M. Nagaraja Kumar (raja@incois.gov.in)]
- Indonesia [Budi Sulistiyo (budisul@yahoo.com); Tukul Rameyo Adi (trameyo_adi@yahoo.com)]
- Iran [Abbas Nobakhti (a_nobakhti@inco.ac.ir)]
- Italy [Nicolas Hoepffner (nicolas.hoepffner@jrc.ec.europa.eu)]
- Malaysia [Mabel Manjaji Matsumoto (mabel@ums.edu.my, mmm408@gmail.com)]
- Maldives [M Shiham Adam (msadam@mrc.gov.mv)]
- Sri Lanka [Kanthi K A S Yapa (kanthi@phy.ruh.ac.lk)]
- Myanmay CHIT Kyaw (chitkyaw.dmh@gmail.com)
- Mervyn Lynch
- Arul

KEY Project

- Recommended that the KEY project is important for the IOGOOS Region and should be taken forward by identifying new Project Coordinator.
- Title might include IOR
- Good to have a small team (Maybe 3 persons representing the 3 ecosystems) to lead the project – Prof. L. P. Jayatissa; Secretariat and Coordinator to write to the participating members of the project and seek their participation to be part of the core working group)
- Possible Links with BOBLME and SIBER Projects
- Have a look at the latest initiatives that have come up (CTI, CORDIO, EARTHWATCH) to ensure that there is no duplication
- JRC interested in collaborating with IOGOOS for this project (especially for the eastern african region)
- Workout whereever possible, links with related national and regional programmes that have already been funded in the region (to name a few, Australia's Blue Water, etc.)
- Dr. Mabel Manjaji Matsumoto has come forward to take the role of Project Coordinator
- IOGOOS Secretariat to contact IMS to request for any alternative nomination for the replacement of Dr. Greg Wagner.
- BOBLME suggested that Myanmar might be interested in the Project.
- Representative of Maldives has conveyed that Maldives is interested to participate in this project and could provide the contact details of the respective authority.
- IOGOOS Secretariat to circulate the draft project document to the focal points from all the participating countries and the current working group participants requesting for their active engagement in the project or for appropriate nominations of alternative member. (Preferably one member from each country representing each ecosystem – Mangroves, Seagrasses, Coral Reefs)
- To finalize the project proposal in consultation with the participating members for further submission to the donor agencies.
  - Secretariat to get the contact details of the members from the participating countries: August 2010
  - Considering the project has already taken a good shape, group to work by email to finalise the proposal for submission to donor agencies : end - 2010

Monitoring of Shoreline Changes

- Recommended to take forward the shoreline change monitoring project.
- The working group members volunteered to communicate with Dr. Kamal Tennakoon, PL of the Project to take further forward
- Bangladesh has come forward to provide the case studies on the shoreline changes to include in the Project proposal and requested for including in the Shoreline Changes
- Maldives will be interested in the Project
- Arul, Sri Lanka will share a report on the work done in SL
- IOGOOS Secretariat to communicate to the focal points from all the participating countries and the current working group participants requesting for their active engagement in the project or for appropriate nominations of alternative members. IOGOOS Secretariat will circulate the draft project document to the above focal points.
- Look at the EU funded projects funded by the shoreline management agencies (get reference from Dr. Nick Hoepffner)
- Methodology to be finalised…
- To finalize the project proposal in consultation with the participating members for further submission to the donor agencies.
  - Secretariat to get the contact details of the members from the participating countries: August 2010
  - Considering that the project has already taken a good shape, the group to work by email to finalise the proposal for submission to donor agencies : end - 2010

Chlorophyll_a Mapping Project (ChloroGIN)

- Products useful for IOGOOS Member countries and requested to continue providing with the existing Products
- Possible Links with BOBLME and SIBER Projects
- Integration of ChloroGIN-IO with SIBER
- Continue collaboration with Global ChloroGIN
- Provision of new products (PP, HAB's, etc.)
- Enable In-situ time series measurements of core variables among the participating member countries
  - Finalize the Methodology and Protocols
  - Organize Training Programmes
  - Prepare proposal for Funding
- Dr. Kanthi Yapa, Sri Lanka volunteered to prepare the first draft by drawing up inputs from the ChloroGIN proposal submitted to GEO as well as inputs from the initial Participating countries and BOBLME member countries
- First draft to be ready within one month (Sep 2010) and the final proposal be ready by four months (Dec 2010)
- Capactiy Building opportunities
  - BOBLME countries representatives may be invited for Capacity Building training programmes (could be funded by BOBLME)
  - EC-JRC training course on 'Methods and Applications of Ocean Colour remote sensing in coastal and regional seas' during 2011 in Mauritius
  - NF-POGO regional training course on 'Ocean Colour Remote Sensing"
  - Follow up workshop of the one doen by SIS…..

Chlorophyll_a Mapping Project (ChloroGIN)

- **New Products proposed by ChloroGIN**
  - Bloom indicators - timing and magnitude of bloom
  - Frontal zone – mesoscale features
  - PFZs (Potential Fishing Zones); identification of mesoscale features
  - PFTs (Phytoplankton functional types) such as Trichodesmium, coccolithophores,
  - diatoms – e.g. INCOIS making RTI (Red Tide Index) for HABs (Harmful Algal Blooms) as a first step and HAB index in South Africa
  - Water quality related indicators (eutrophication index, water transparency) case study in Europe (Oxyrisk)
  - Primary Production estimates
  - Regional Chl and SST anomalies (implies long satellite data time series)

Donor Agencies

- **GEF**
- **EU**
- **UNEP**