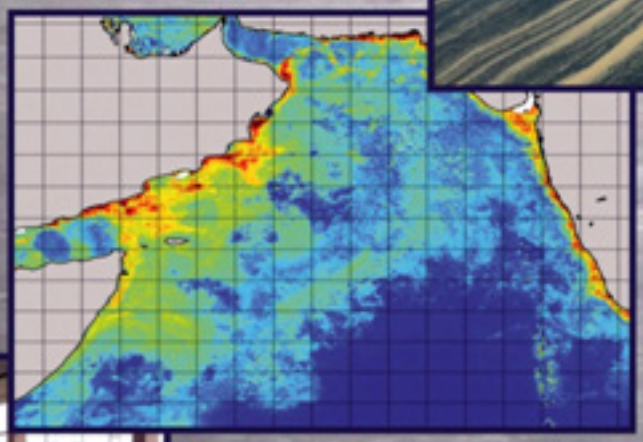
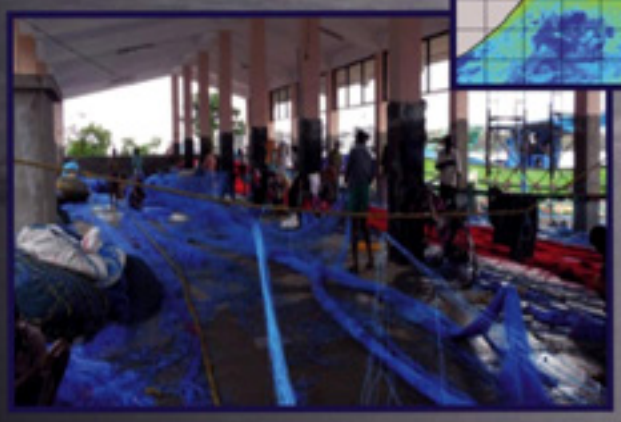
ANNUAL REPORT 2013





NANSEN ENVIRONMENTAL RESEARCH CENTRE (INDIA)

A NON-PROFIT ENVIRONMENTAL AND CLIMATE RESEARCH CENTRE
RECOGNISED BY THE DEPARTMENT OF SCIENTIFIC AND
INDUSTRIAL RESEARCH (DSIR), GOVT. OF INDIA

REPORT FROM THE BOARD FOR 2013

Vision

To serve the society through advancing knowledge on Climate system including Marine and Coastal environment for sustainable development by promoting inter disciplinary research and education cooperation programme in the spirit of Fridtjof Nansen.

Main scientific research areas of NERCI are:

1. Monsoon and ocean variability, Climate change, Sea level variations
2. Marine Ecosystem studies including algal blooms
3. Coastal Zone Management and Societal issues.

Organisation

The Nansen Environmental Research Centre India (NERCI) was established in 1999 as a joint venture between the Indian and Norwegian partners. NERCI conducts basic and applied research in ocean and atmospheric sciences funded by national and international agencies, organizations and industry. Core funding is received from the Nansen Centre and the Nansen Scientific Society, Bergen, Norway. NERCI is a non-profit research centre within the Nansen Group of research centres and is registered with DSIR (Department of Scientific and Industrial Research) of Ministry of Science and Technology, Govt. of India as a Scientific Industrial Research Organization (SIRO) from 2012 onwards.

The Nansen group of international research institutes include:

- Nansen Environmental and Remote Sensing Centre (NERSC), Bergen, Norway
- Nansen International Environmental a nd Remote Sensing Centre, St. Petersburg, Russia
- Nansen-Zhu International Research Centre, Beijing, China
- Nansen-Tutu Centre for Marine Environmental Research, Cape Town, South Africa
- Nansen-Bangladesh International Centre for Coastal Ocean and Climate Studies, Dhaka, Bangladesh
- Nansen Scientific Society, Bergen, Norway
- Terra Orbit AS – a research company, Bergen, Norway.

NERCI capitalizes on the joint scientific expertise of the Nansen Group, which has about 200 staff including 60 Ph.D. and Master students in the various centres.

Staff

The Centre has at present a staff of 25, which includes four full time scientists, four associate scientists, three consultant scientists, two research associates, six full time PhD. students, including four project fellows and two administrative staff

Scientists

Ajith Joseph. K – Oceanography & Remote sensing Nandini Menon. N – Marine ecosystem studies Syam Sankar – Climate & Ecosystem modelling Bindu. G – Climate change

Associate Scientists

N. R. Menon – Marine ecosystem & Coastal zone management

P. V. Joseph – Monsoon & Ocean variability, sea level variations
Ola. M. Johannessen – Oceanography & Climate

Lasse H Pettersson – Oceanography & Remote sensing
K.Shadananan Nair - Hydro meteorology & Coastal zone management

Administrative Staff

Hariharan. K. S. – Finance, Manuel Prakasia - Assistant

Consultant scientists

Harenduprakash. L – Ocean modelling,
K. K. C. Nair – Marine Biology

Research Associates

Abish. B – Monsoon studies

Shalin Saleem – Ecosystem modelling & Data Assimilation

Project fellows

Archana Nair – Climate studies
Sreevidya Radhakrishnan – Marine Ecosystem studies
Mary Swapna George- Ocean modelling
Smitha A- Oceanography and Modelling

Nansen Environmental Research Centre, (India), Kochi, Kerala. Founded in 1999 http:// www.nerci.in

Board of Directors

Prof. Ola M. Johannessen (Chairman), Nansen Fellow, NERSC and President of the Nansen Scientific Society, (NSS), Norway.
Prof. N. R. Menon, (Co-Chairman), Professor Emeritus, CUSAT, Kochi, India.
Lasse H. Pettersson (Vice Chairman), Director of International Cooperation, NERSC, Norway.
Mrs. Bente E. Johannessen, Administrator, NSS
Dr. K. Ajith Joseph, Executive Director, NERCI.
Prof. P. V. Joseph, Director (Rtd), India Meteorological Department, Kochi, India, Professor Emeritus, CUSAT.
Dr. N. Nandini Menon, Deputy Director, NERCI.

Scientific Research Advisory Board

Prof. N.R. Menon (Chairman), Professor Emeritus, School of Marine Sciences, CUSAT, Kochi, India.
Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences, Govt. of India, New Delhi.
Prof. Ola M. Johannessen, Nansen Fellow and President of the Nansen Scientific Society, Norway.
Prof. P.V. Joseph, Director (Rtd.), India Meteorological Department, Kochi, India, Professor Emeritus, CUSAT.
Lasse H. Pettersson, Director of International Cooperation, NERSC, Bergen, Norway.
Prof. B. Madhusoodana Kurup, Vice -Chancellor, KUFOS.
Dr. N.P.Kurian, Director, Centre for Earth Science Studies. Trivandrum
Dr. Laurent Bertino, Research Director, Mohn-Sverdrup Center for Global Ocean Studies and Operational Oceanography, NERSC, Bergen, Norway.
Dr. M. Ramalingam, Former Director, Institute of Remote Sensing, Anna University, Chennai, India
Prof. T. Balasubramanian, Dean, Faculty of Marine Sciences, Annammalai University.
Dr. K. Ajith Joseph, Executive Director, NERCI.
Dr. Nandini Menon, Deputy Director and Member Secretary, NERCI.

Honorary Member

Mr. Thomas Mathew, Advisor (Rtd), NORINCO Pvt. Limited, Kochi, India.

Coverpage:

Fisheries harbour, Output from the PP(Primary Productivity) model,Trichodesmium erythraeum bloom in the Arabian sea against the backdrop of Muzhupilangad, sandy beach (Kerala) during the SW monsoon.

Office and Environment

NERCI is an equal opportunity employer in which 35% of the research staff are females. Among the PhD students and project fellows, 44% are females. In 2013, NERCI has improved the gender equality ratio in the organisation.

The NERCI Scientific Research Advisory Board monitors the research activities of NERCI and gives guidance for R&D activities as well as promotion of education and interaction with institutes in India and abroad.

The office maintains an eco-friendly atmosphere with improved research infrastructure facility and working environment for the staff. An economy and environment committee with the Chairman, Vice chairman and the Executive Director as members supports the management of the Centre.

Scientific Outreach

Outreach is actively done through press releases, popular science lectures by conducting international and national workshops, conferences and newsletters. Awareness campaigns are also conducted as part of ongoing projects.

National and International Cooperation

Memorandum of Understanding (MoU) between Cochin University of Science And Technology (CUSAT), Kerala University of Fisheries and Ocean Studies (KUFOS), Toc H Institute of Science and Technology (TIST), Nansen Environmental Remote Sensing Center (NERSC), Bergen, Norway and NERCI is in operation and that with Indian National Centre for Ocean Information Services (INCOIS) in Hyderabad and Anna University are under renewal. The MoU focuses on development of bilateral cooperation in satellite remote sensing, operational oceanography and ocean modelling.

Under the MoU between Anna University, Chennai, Nansen Environmental and Remote Sensing Centre, Bergen, and NERCI, one student *Mrs. Lakshmi Srikantha* defended her thesis on *Development of Statistical cyclones intensity prediction model for the Bay of Bengal region*. She published a paper "*A study on the influence of oceanic and atmospheric parameters on trpical cyclones in the Bay of Bengal*" in *European Journal of Scientific research jointly* with NERSC scientists. Another Ph.D student Mr. Madhavan has completed his doctoral work for submission in 2014.

The fellowship programme of Nansen Scientific Society is implemented at the Faculty of Marine Sciences, Cochin University of Science and Technology under the MoU signed between NERSC, CUSAT and NERCI. Currently three students are doing PhD under this scheme. Their research work is conducted at the Cochin University of Science and Technology (CUSAT), NERSC (Norway) and NERCI with funding from Nansen Scientific Society, Bergen, Norway.
Two international workshops and one winter school were organised jointly with NERSC, NSS scientists and other EU partners, the details are available in this report.

In 2013, NERCI improved its research infrastructure both in hardware and software with lab facilities – Satlantic Radiometer, UV Spectrophotometer, High end server for running Ocean and ecosystem models, developing regional algorithms for satellite applications and have installed latest versions of ArcGis and Matlab under the Indo-Mareclim and India-Clim projects.

Awards and Recognition

Prof. N. R. Menon receives the Prof. N. Balakrishnan Nair award for Environmental Excellence from Dr. Daniel Pauly, Professor, University of British Columbia, Canada.

Prof. N.R. Menon, Co-Chairman of NERCI Director Board, Co-ordinator of EU-FP7 Project, INDO-MARECLIM, at NERCI and Emeritus Professor, CUSAT received Prof. N. Balakrishnan Nair Award for "Environmental Excellence". This award was presented to Prof. N.R. Menon by Dr. Daniel Pauly, Professor at University of British Columbia, Canada, during the International Conference on Ecosystem conservation,Climate change and Sustainable Development jointly organised by Department of Aquatic Biology and Fisheries, Kerala University and Directorate of Environment and Climate change, Govt. of Kerala from October 3-5, 2013.

Exchange Visits

During 2013, ten scientists including NERSC Scientists, Ola M.Johannessen, Lasse H.Pettersson, Annette Samuelsen, Yongqi Gao, Jan Even Nilsen and Ph.D student Ms. Lea Svendsen visited NERCI. Similarly, NERCI scientists P.V.Joseph, Syam Sankar, Ajith Joseph have visited NERSC several weeks to work under collaborative projects IndiaClim and EU INDO-MARECLIM. Additionally, research students and scientists from partner institutions of INDO-MARECLIM Project, i.e., PML (U.K), NERSC (Norway), Alterra (Netherlands) and IFREMER (France) have visited NERCI for periods ranging from weeks to several months. Ms. Smitha. A, project fellow at NERCI was awarded POGO- SCOR fellowship to study "satellite data processing, interpretation and modelling of primary productivity" at Plymouth Marine Lab (PML), U.K under the supervision of Prof. Trevor Platt for a period of one month,October, 2013.

Visit of trainee Meteorology officers from Indian Navy to NERCI research facilities in October, 2013

The new group of Meteorology officers at School of Naval Oceanology & Meteorology of Indian Navy was given a half day seminar on Recent trends in Ocean Modelling and variabilities of Indian monsoon at NERCI. Prof.PV Joseph, Dr. Harenduprakash.L, Dr. Ajith Joseph and Ms. Swapna George gave the lectures.

ONGOING PROJECTS

NERCI has the following ongoing external funded projects from agencies like Directorate of Environment and Climate Change, Govt. of Kerala, DST, SAC and ISRO. International joint projects like EU-FP7 Programme and Norwegian Research Council Programme, Ph.D programme by Nansen Scientific Society and UNEP are also underway.

International Joint Research Projects

EU INDO-MARECLIM: Indo-European Research facilities for Studies on Marine Ecosystem and Climate in India.

INDIA-CLIM: Decadal to multi-decadal variability in the Indian Monsoon Rainfall and teleconnection with Atlantic Multidecadal Oscillation (AMO)

Regional climate change issues and adaptation measures for low lying regions in the context of future sea level rise National joint research projects

Application of Altimetry (AltiKa) and Ocean Color (Oceansat II) in the studies of meso-scale features of the South-eastern Arabian Sea

Effect of house boats on Vembanad lake ecosystem – an EIA study

Commercial use of biomass from Musa sp. (banana) to reduce its negative impact on environmental quality of Kuttanad ecosystem

PhD students under joint projects

Six full time and two part time doctoral students are currently carrying out their research work jointly at CUSAT or in affiliation with NERCI and NERSC including the Nansen Scientific Society Ph.D fellowship programme.

Ajin A M – INDO-MARECLIM fellow doing PhD under the guidance of Prof. N. R. Menon at CUSAT.

Topic of research: Marine ecosystem studies and biodiversity concepts.

Sachin Pavithran – INDO-MARECLIM fellow, doing PhD under the guidance of Prof. K. C. Sankaranarayanan at CUSAT.

Topic of research: Pressures, trends and impacts in the coastal zones; interactions between socio-economic and natural systems.

Smitha A- INDO-MARECLIM fellow and part-time PhD student at CUSAT under the guidance of Prof. H. S. Ram Mohan.

Topic of research: Wind induced upwelling and the response of surface chlorophyll in the Bay of Bengal

Mary Swapna George –Part-time PhD student at the Nansen Environmental and Remote Sensing Center (NERSC), affiliated to University of Bergen, Norway. Her main supervisor is Prof. Ola M Johannessen and co-guide is Dr. Laurent Bertino.

Topic of research: Indian ocean modelling using HYCOM.

Nashad. M -Nansen Scientific Society fellow, doing PhD under the guidance of Prof. N. R. Menon at CUSAT. Co-guide at NERCI Dr. Nandini Menon. N. Co-guide at NERSC – Lasse H Pettersson.

Topic of research: Monitoring and modelling of Harmful algal blooms along the South West coast of India.

Shinu Sheela Wilson – Nansen Scientific Society fellow, doing PhD under the guidance of Prof. Mohankumar. K at CUSAT. Co- guides at NERCI – Dr. P. V. Joseph and Dr. Ajith Joseph. Co-guides at NERSC Prof. Ola. M. Johannessen and Yongqi Gao.

Topic of research: Inter annual variability of monsoon over India.

Muhammed Shafeeque - Junior Research Fellow in the SAC-ISRO joint project registered for PhD under Prof.A.N Balchand of CUSAT. **Topic of research**: **Application of satellite altimetry (Altika) and Ocean Colour (Oceansat II) in the studies of mesoscale features of the South-eastern Arabian Sea.**

R. Renju - State Committee on Science Technology and Environment (STEC) Fellow, Govt. of Kerala doing research under the guidance of Prof. N. R. Menon at CUSAT.

Topic of research -Taxonomy and Systematics of Benthic Foraminiferans from the South-West Coast of India.

Funding

NERCI is a non-profit research organisation registered under Article 25 and accredited SIRO status under DSIR. Mainly funded by Nansen Environmental and Remote Sensing Center, Norway and Nansen Scientific Society. It receives funding through projects from European Commission, Norwegian Research Council, United Nations Environmental Programme (UNEP) and other national agencies like Department of Science and Technology, Govt. of India, Space Application Centre, ISRO and Dept of Environment and Climate Change, Govt. of Kerala.

Prospects for 2014

NERCI enters 2014 with plans for increasing their national and international cooperation, particularly strengthening the cooperation within the Nansen Group and other Indo- European research institutions. The ongoing EU FP7 project *INDO-MARECLIM (Indo- European Research Facilities for Studies on Marine Ecosystem and Climate in India*) has strengthen the research infrastructure and increase the research cooperation with European scientists. The Research Council of Norway project *INDIA-CLIM (Decadal to multi- decadal variability in the Indian Monsoon Rainfall and teleconnection with Atlantic Multidecadal Oscillation*) is an important part of the bilateral Indo-Norwegian cooperation in climate research. Scientists and PhD students from NERCI will also visit European research institutions particularly NERSC, Bergen and Nansen Scientific Society to work on ocean and atmospheric modelling, ecosystem modelling and satellite Earth observation research with Indian and European partners.

Cochin 19th May 2014

Board of Directors

International Joint Research Projects

EU INDO-MARECLIM:Indo-European Research facilities for Studies on Marine Ecosystem and Climate in India.

Coordinator- Prof. N. R. Menon (NERCI), Deputy Coordinator- Lasse H. Pettersson(NERSC), Project Manager- Ajith Joseph, K. (NERCI), Chairman, Steering Committee- Prof. Ola M. Johannessen (NERSC), funded by EU-FP7 programme.

INDO-MARECLIM aims at analyzing and understanding some of the challenges of the Indian Ocean and the Indian subcontinent under past, current and future global change processes, by addressing three related and complementary scientific fields of research. http://www.indomareclim-nerci.in

INDIA-CLIM: Decadal to multi-decadal variability in the Indian Monsoon Rainfall and teleconnection with Atlantic Multidecadal Oscillation (AMO)

Project Leader – Prof. Ola M. Johannessen (NERSC) Co- Principal Investigator - Prof. P. V. Joseph, funded by Norwegian Research Council.

INDIA-CLIM aims at analysing the Decadal to multi- decadal variability in the Indian Monsoon Rainfall and teleconnection with Atlantic Multidecadal Oscillation (AMO) funded by Norwegian Research Council and in kind contribution from NERSC.

Regional climate change issues and adaptation measures for low lying regions in the context of future sea level rise

Principal Investigator - Dr. K. Ajith Joseph, NERCI Co-PI- Dr. Shadananan Nair, NERCI-CEREM

The main objective is to study the regional climate change issues and adaptation measures to future sea level changes of a region which is lying below the mean sea level to address: drinking water problems and salt water intrusion, land use pattern and identification of proper agriculture practices and disaster preparedness. Funded by UNEP-APFED programme.

National joint research projects

Application of Altimetry (AltiKa) and Ocean Color (Oceansat in the studies of meso-scale features of the South-eastern Arabian Sea

Principal Investigator – Prof. A. N. Balchand, CUSAT Co-PI – Dr. K. Ajith Joseph, NERCI

The main objective of this study is to understand upwelling dynamics and its effect on sea level variability and the dissipation of algae blooms in the South-eastern Arabian Sea in relation to mesoscale features of Southwest coast of India. Funded by Space Application Centre (SAC-ISRO).

Effect of house boats on Vembanad lake ecosystem- an EIA study

Principal investigator- Dr. Nandini Menon. N, Co-investigators- Prof. N. R. Menon and Dr. Ajith Joseph The proposal is a scientific attempt to proclaim the significant role of houseboats, viewed and projected as integral part of Kerala tourism in contaminating the ecosystem.The study area of the proposed project includes the part of Vembanad lake between Punnamada to Thanneermukkom bund, along which majority of the houseboats ply. Funded by Directorate of Environment & Climate Change, Govt. of Kerala.

Commercial use of biomass from Musa sp. (banana) to reduce its negative impact on environmental quality of Kuttanad ecosystem

Principal investigator – Dr. K. Suresh, TocH Institute of Science and Technology, Kochi

Co-investigator - Dr. Nandini Menon. N, NERCI

The main objective of this project is to find commercial use of biomass of Musa sp. by extraction of fibre from Banana plant and training the rural women on the effective utilization of bio-waste from banana plant for the production of organic toys and other eco-friendly products for income generation and popularisation of the products through various agencies. This proposal is the first of its kind to take on a potential solution to water pollution on a massive scale and investigate its net benefits/costs compared to the status quo of the financially backward majority of the population. Funded by Dept. of Science and Technology.

Key Research Areas

The current focus of research at NERCI are on the following:

1. Monsoon and ocean variability, Climate change and Sea level variation

Co-heads - Prof. P. V. Joseph, NERCI and Prof. Ola Johannessen, NERCI/NERSC

Research Topics:

- Relation between Atlantic Multi-decadal Oscillation and the Indian Summer Monsoon Rainfall
- The role of Indian Ocean in the intra-seasonal and inter annual variability of Indian monsoon rainfall
- The rapid warming of the equatorial Indian Ocean and its impact on the regional climate
- The cold pool of the Bay of Bengal during the summer monsoon season
- Sea level variations in the Indian Ocean.

2. Marine ecosystem studies including algal blooms

(*Co-heads- Prof. N. R. Menon & Dr. Nandini Menon, N., NERCI, Lasse H. Pettersson, Dr. A Samuelsen, NERSC*)

Research Topics:

- Vulnerability of marine ecosystems to climate changes and its relevance to marine food resources
- The effect of seasonal and inter-annual monsoon variations on primary production and higher trophic levels of the food in the Indian Ocean
- Increased incidence of Harmful Algal Bloom (HAB) in the Indian Exclusive Economic Zone (EEZ) and the relevance of physical and chemical oceanographic parameters
- Modelling studies and possible development of early warning systems.

3. Coastal zone Management and Societal issues

(*Co-heads- Prof. N R Menon and Dr. K. Ajith Joseph, NERCI; Lasse H Pettersson, NERCI/NERSC*)

Research Topics:

- Contemporary challenges in Coastal Zone Management in India including the impact on coastal society
- Focus on the problem in fisheries sector and help in bringing up guidelines to policy makers in fishing sector
- The formulation of more meaningful coastal zone regulations of regional relevance
- Utilisation of satellite data for the development of decision making tools with linkage to the other research areas

SCIENCE REPORT FOR 2013

Interannual variability of chlorophyll-a along the southwest coast of India

Ajith Joseph, K[1]. and Lasse H.Pettersson[2]

1. *Nansen Environmental Research Centre (India), Kochi*
2. *Nansen Environmental and Remote Sensing Center, Norway*

The interannual variability of chlorophyll concentration along the southwest coast of India is studied using remote-sensing data from SeaW iFS. The data are analysed in conjunction with satellite measured sea surface winds. The satellite measured chlorophyll data for a period of 10 years from 1998 to 2007 were made use of for indexing the maximum offshore extent of chlorophyll along the coast for each month. From the empirical orthogonal functional analysis of chlorophyll data, it is observed that the dominant mode is annual. Interestingly, intraseasonal variability and the influence of climatic events like El Niño are observed in the secondary principle component of the time series. The variability of chlorophyll coincided well with variability of Ekman transport all along the coast with higher chlorophyll >1 mg /m^3 when the Ekman transport is greater than 1000 kg/m/s (FIg. 1 (a,b,c,d). During the years 2005 2007, reduction in the meridional along shore component of wind resulted in reduction of Ekman transport, the phenomenon which leads to a decrease in chlorophyll. This may be due to the reduction in the amount of nutrients that entrained to surface layers during less intense upwelling of the southwest monsoon during this period. The chlorophyll-a is minimum when Ekman transport is less than 0.5 kg/m/s on the normalized scale. For higher values of Ekman transport, the c hlorophyll concentration is higher indicating the contribution of wind in enhancing the already upwelled chlorophyll production. The smaller value of R2 infers that there exist other factors in augmenting the surface chlorophyll. The enhanced knowledge on the offshore extent and the intraseasonal and interannual variability of chlorophyll can provide valuable inputs on fisheries and primary productivity of this region.

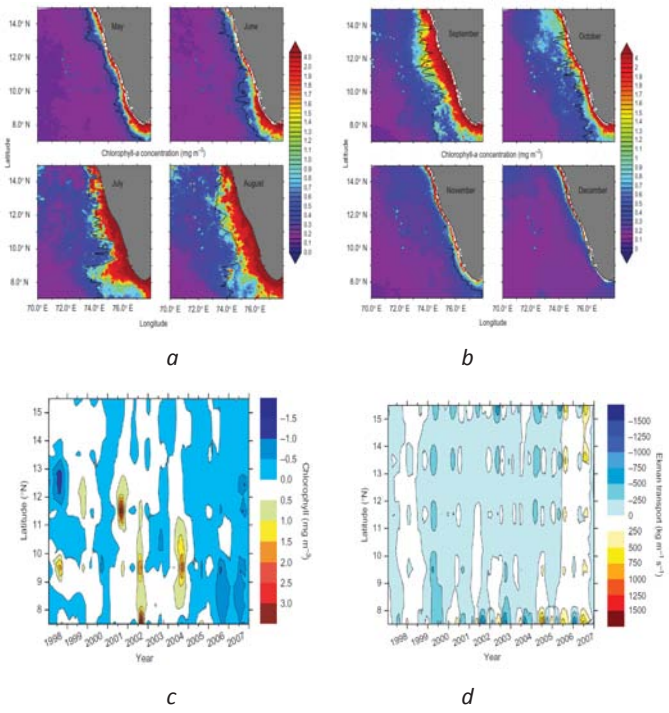


Fig. 1 (a) Chlorophyll extension during May, June, July, and August. The dark contour indicates the offshore extension limit of chlorophyll at <"0.95 mg m-^{3})
(b) Chlorophyll extension during September, October, November, and December.
(c) Chlorophyll anomaly along 200 m isobaths as a function of latitude and time.
(d) Ekman transport anomaly along 200 m isobaths as function of latitude and time

(Work done as part of OCEANSAT II data utilisation project and published as :Chiranjivi Jayaram, Ajith Joseph K and Balchand A N.,2013. Interannual variability of chlorophyll-a concentration along the southwest coast of India, International Journal of Remote Sensing, Vol. 34(11), 3820-3831)

Variability of Summer Monsoon Rainfall in India on Inter-Annual and Decadal Time Scales

Joseph P.V.[1], Bindu G[1]., Archana Nair[1] and Shinu S.W[1,2].

1. *Nans*en Environmental research Centre (India), Kochi
2. Dept. *Of Atmospheric Sciences, Cochin University of Science and Technology, Kochi*

Indian Summer Monsoon Rainfall (ISMR) exhibits a prominent inter-annual variability known as troposphere biennial oscillation. A season of deficient June to September monsoon rainfall in India is followed by warm sea surface temprature (SST) anomalies over the tropical Indian

Ocean and cold SST anomalies over the western Pacific Ocean. These anomalies persist until the following monsoon, which yields normal or excessive rainfall. Monsoon rainfall in India has shown decadal variability in the form of 30 year epochs of alternately occurring frequent and infrequent drought monsoons since 1841, when rainfall measurements began in India. Decadal oscillations of monsoon rainfall and the well known decadal oscillations in SSTs of the Atlantic and Pacific oceans have the same period of approximately 60 years and nearly the same temporal phase. In both of these variabilities, anomalies in monsoon heat source, such as deep convection, and middle latitude westerlies of the upper troposphere over south Asia have prominent roles. In drought monsoons wave number 6 has a trough over Northwest India and another trough close to Japanese Islands. DRY monsoons are associated with such a wave number-6 trough from the month of May and through the monsoon season (Fig. 2). The LCC (Linear correlation coefficient) is large and statistically significant.

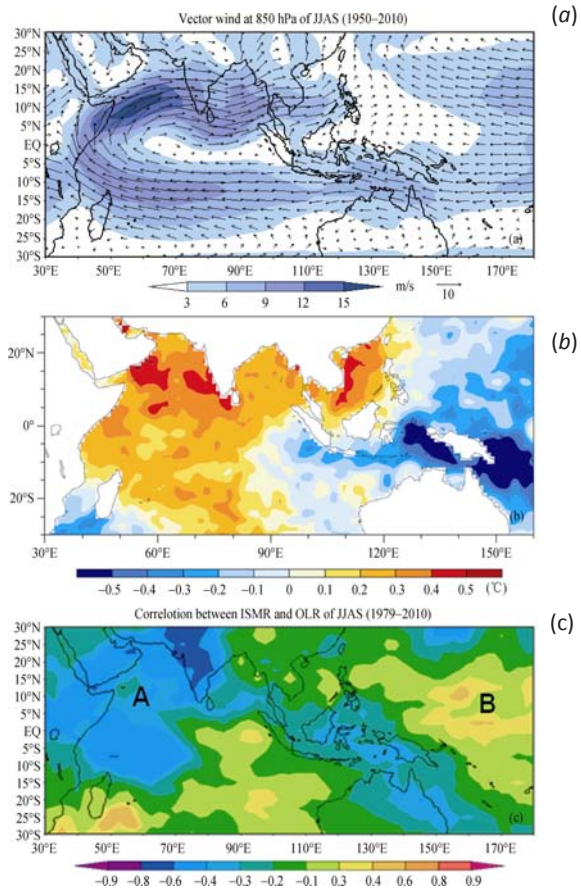


Figure 2 (a) Mean low level jetstream of June to September (1950–2010) at 850 hPa level with isotachs of the wind magnitude in m s–1 shaded and the vector wind in m s–1 marked by the arrows; (b) Mean HadISST anomaly of September to November as composite of five severe drought mon- soons of 1965, 1972, 1979, 1982, and 1987; (c) Correlation between ISMR and mean OLR of June to September using data of 1979 to 2010 showing the two poles of convection (monsoon heat source) anomaly of Indian (A) and West Pacific (B) oceans.

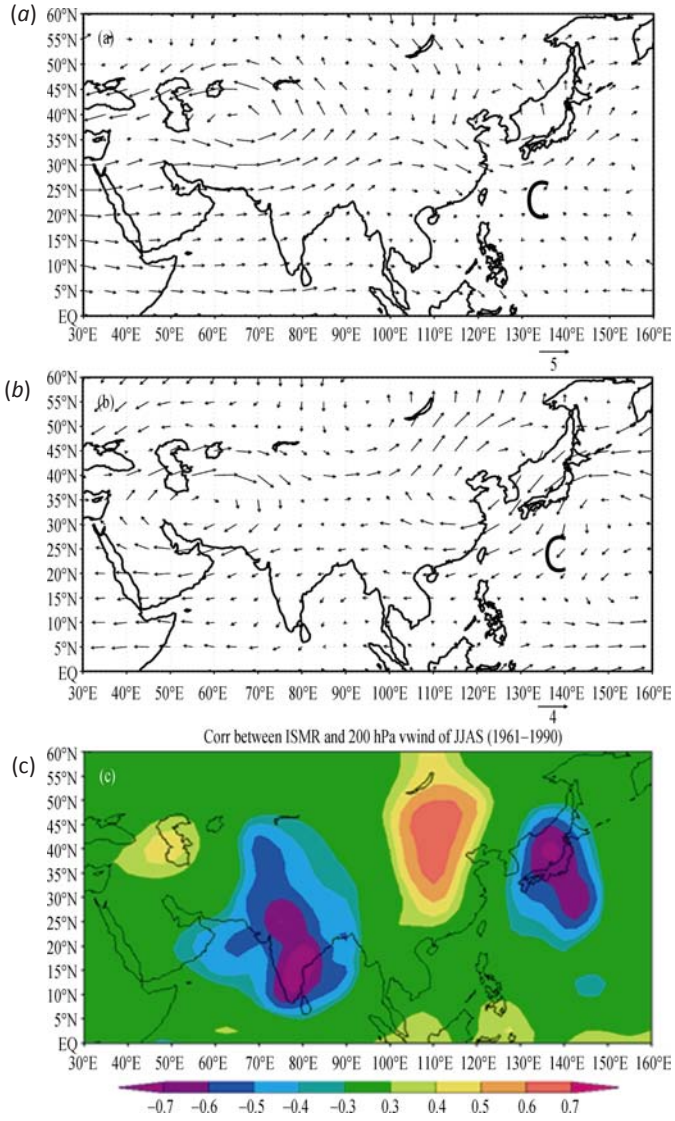


Figure 3 (a) Vector wind anomaly in m s–1 at 200 hPa level of DRY monsoon (JJAS) composite of 1965,1972, 1979, 1982, and 1987; (b) Vector wind anomaly in m s–1 at 200 hPa level of WET monsoon (JJAS) composite of 1961, 1970, 1975, 1983, and 1988; (c) Linear correlation coefficient (LCC) between ISMR and 200 hPa meridional wind component of June to September of 1961 to 1990 showing the Asia-Pacific wave (wave number 6).

(*Work done as part of INDIACLIM project and published as : Porathur Vareed Joseph, Bindu Gokulapalan, Archana Nair, and Shinu Sheela Wilson, 2013, 'Variability of Summer Monsoon Rainfall in India on Inter-Annual And Decadal Time Scales' , Atmospheric and oceanic science letters, vol. 6, No. 5, 1-6*)

Weakening Trend of the Tropical Easterly Jet Stream of the Boreal Summer Monsoon Season 1950-2009

B. Abish [1] , P. V. Joseph [1], Ola M. Johannessen [2]

1. *Nansen Environmental Research Centre (India), Kochi*
2. *Nansen Environmental and Remote Sensing Center, and Nansen Scientific Society, Norway*

Recent research has reported that the tropical easterly jet stream (TEJ) of the boreal summer monsoon season is weakening(Fig. 4). It may be noted that from decade 1970-79 to decade 1980-89, the high speed center of TEJ (innermost isotach) showed very little change in area and strength. This is the period around the well known "Climate shift" of 1976-1978. The analysis herein using 60 yr(1950–2009) of data reveals that this weakening of the TEJ is due to the decreasing trend in the upper tropospheric meridional temperature gradient over the area covered by the TEJ (Fig. 5). During this period, the upper troposphere over the equatorial Indian Ocean has warmed due to enhanced deep moist convection associated with the rapid warming of the equatorial Indian Ocean. At the same time, a cooling of the upper troposphere has taken place over the Northern Hemisphere subtropics including the Tibetan anticyclone. The simultaneous cooling of the subtropics and the equatorial heating has caused a decrease in the upper tropospheric meridional thermal gradient. The consequent reduction in the strength of the easterly thermal wind has resulted in the weakening of the TEJ.

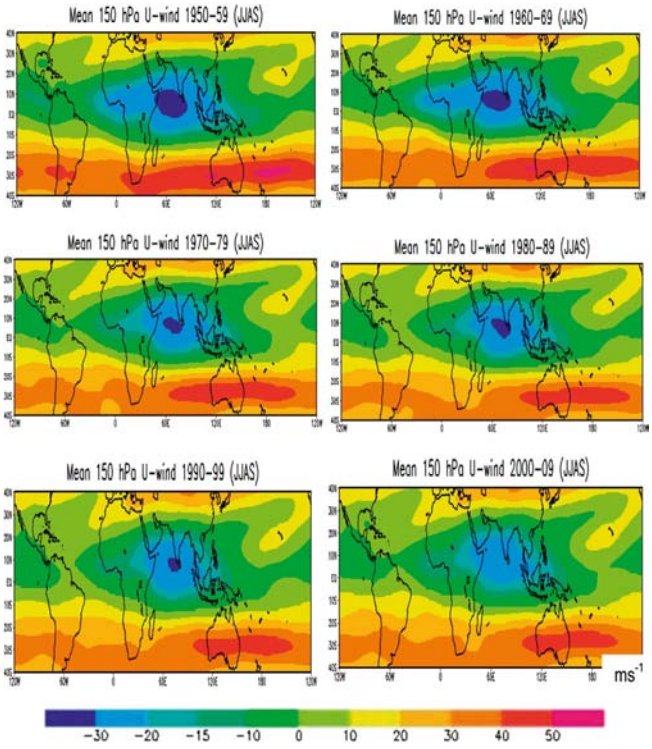


Fig. 4: Mean June–September wind (m s21)at 150 hPa of each decade for the period 1950–2009 showing the steady decrease in the area covered and strength of the TEJ.

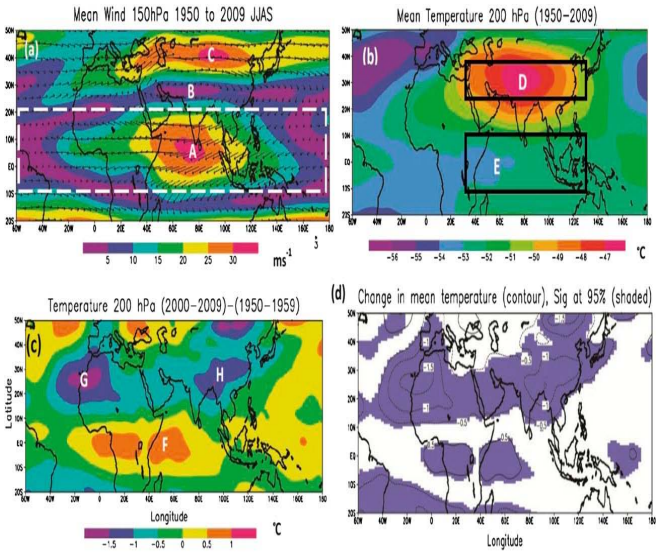


Fig. 5: Climatological mean of June–September (JJAS) for the period 1950– 2009.
(a) Wind at 150 hPa in m/s is shown by the vectors and magnitudes shown in color. The dashed line box marked A denotes the area covered by the TEJ. To its north are the Tibetan anticyclone (B)and the Asian subtropical jet stream (C).
(b)Mean temperature at 200 hPa for the subtropical region (D) and for the equatorial area (E).
(c) Temperature change at 200hPa (2000- 09 minus 1950-59) Here G and H reresent the subtropical cooling and Fdenotes equatorial warming. (d) The shaded grid cells denote the regions of statistical significace at 95%level

(*Work done as part of INDO-MARECLIM project and Published as :Abish, B., Joseph, P.V. and. Johannessen, O.M., 2013. Weakening Trend of the Tropical Easterly Jetstream of the Boreal Summer Monsoon season 1950 - 2009, Journal of Climate (JCLI-D-13-00440)*

Marine ecosystem indicators from the biogeochemical model ERSEM: Sensitivity analysis

Syam Sankar[1], Nandini Menon. N[1]and Annette Samuelsen[2]

1. *Nansen Environmental Research Centre (India), Kochi*
2. *Nansen Environmental Remote Sensing Center, Norway*

Ecological indicators are functions of environmental variables (e.g. nutrient concentrations, primary production, etc.) that are used increasingly to describe the status of marine ecosystems. Marine ecosystem models have also been proposed as potential tools to estimate ecological indicators, for scientific and management purposes. To use marine ecosystem models for the prediction of ecological indicators, the reliability of the model has to be evaluated through a quantitative assessment of the model performance. An important part of this assessment is the understanding of how the model output is affected by or is"sensitive" to the choice of the parameter values, which is referred to as sensitivity analyses (SA).

Oxygen concentration is an important indicator of the health of marine ecosystems. In this study we investigate if and to what

extent the simulation of the oxygen minimum zone (OMZ) is affected by the changes in biogeochemical model parameters. To this end, a 1- dimensional coupled physical-biogeochemical model (GOTM- ERSEM) has been implemented in the central Arabian sea (13°N, 65°E) in simulations for years with variable monsoons – 2002 with deficit monsoon and 2005 with normal monsoon. Model was run using data from ECMWF (meteorological data and cloud cover), HYCOM (temperature and salinity profiles), WOD09 (DO, nitrate, phosphate, silicate vertical profiles) and Asia-Pacific data Research Centre (Fresh water flux). A sensitivity analysis (SA) of the simulated OMZ was carried out using the Morris method, applied with 333 ecosystem parameters of ERSEM, subdivided into 22 groups of parameters characterizing different model processes. The groups are as given in Table 1.

The group 21, comprising the light extinction parameters were found to have the maximum influence on DO in the study area. Breves et al (2003) have observed enhanced red fluorescence emission in the OMZ of Arabian Sea and have attributed the same to the light extinction of bacterioplankton. Naqvi (1994) has shown through measurements of nitrite, particulate protein, bacterial abundance and the beam attenuation the presence of a turbid layer at intermediate depths of the Arabian Sea which does not seem to be restricted to any special water masses.

Table 1: List of groups used for the sensitivity analysis

Group number	Description	No.of parameters
1	Photosynthetic parameters	20
2	Metabolic C loss parameters	5
3	Lost C by lysis parameters	4
4	Nutrient parameters	50
5	Q10 parameters: of phytoplankton	4
6	Photosynthetically available fraction of irradiation	1
7	Other primary production parameters	17
8	Max. sp. gross uptake	1
9	Bacterial loss terms	4
10	Nutrient uptake / remineralisation	4
11	Abiotic remineralisation	12
12	Other bacteria parameters	3
13	Max. zooplankton uptake	13
14	Mesozooplankton loss terms	21
15	Q10 of zooplankton	7
16	Zooplankton nutrient quotas	6
17	Food matrix parameters	20
18	Benthic return parameters	4
19	Subsiding velocity of phytoplankton, DOM and POM	7
20	Cellular structural parameters	4
21	Light parameters	8
22	Others (without any output)	118
	Total	333

The present results also point to the fact that intense denitrification in the Arabian Sea is associated with a large amount of bacteria causing the increased beam attenuation at these depths. Dissolved organic matter as well as senescent algae, cyanobacteria, marine snow all could contribute to light extinction in the OMZ (Broenkov et al., 1992). The more the attenuating factors, wider is the OMZ.

Q10 parameters (Group 5), representing the regulating temperature factors for different classes of phytoplankton were found to be the second highest sensitivity index on the simulation of the annual minimum oxygen concentration. The physical transport process is a direct consequence of the annual cycle of solar radiation and water column stratification which drive the primary production, and, consequently, the seasonality of the biomass and respiration of all the living organisms. Thus, the seasonal stratification of the water column can determine cycles in the vertical profiles of the oxygen concentrations.

Metabolic C loss of phytoplankton (Group 2), Bacterial metabolic parameters and Bacterial loss terms (Groups 12 and 9 respectively) followed in the ranking. Studies to determine the percentage of export production from surface production to depths beyond 100m in the Arabian Sea have implied export percentages in the region to be 5–15%, more typically below 10%. This shows that even though there is no large metabolic imbalance in the water column, variations in GPP and NPP has a significant influence on the C export and in turn, the OMZ of the region. Higher the temperature of seawater, the higher the resulting specific rate of nitrification. On linking nitrification to both temperature and oxygen availability, it is seen that the significance of nitrification becomes high in hypoxic environments such as oxygen minimum zones (Ferna'ndez et al.,2009) and sea floor sediments(Soetaert al.,2000) Jayakumar et al (2009) based on their obvesrvations in Arabian Sea have shown that as OMZs expand, microbial abundance potentially decreases in these areas of the ocean and they become dominated by a few different heterotrophic denitrifying species.

The results obtained for sensitivity analysis for the years 2002 and 2005 (Fig 6a &6b) which were drastically different in the case of physical forcings show that even though the sources and sinks of oxygen in the Arabian sea on a seasonal basis are dominated by the mean vertical and lateral advection (Ekman pumping and monsoonal currents), on an annual time scale, the biological sink is counterbalanced by the supply of oxygen by mesoscale features like eddies and filaments. These results were corroborated by the findings of Resplandy et al. (2012). The study helped to understand how the variation in the minimum O2 concentration value can be apportioned to the phytoplankton parameters that are sources of variation.

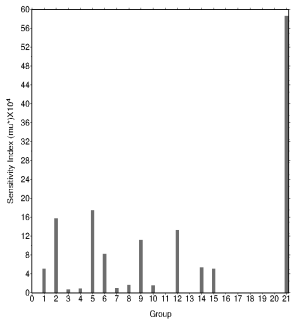


Fig. 6a. Sensitivity analysis for 2002

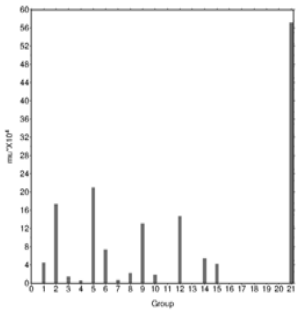


Fig. 6b. Sensitivity analysis for 2005

(The above *Work done as part of INDO-MARECLIM project and submitted for the upcoming International symposium Advances in Marine Ecosystem Research AMEMR at PML from June 30 July 4, 2014*)

Studies on eco-biology of Indian pearl oyster Pinctada fucata (Gould)

Prof. N.R. Menon (Co-Chairman NERCI, Professor Emeritus, School of Marine Sciences, CUSAT)

Taxonomic studies using morphology, anatomy, and shell characteristics have revealed clearly that the taxonomic position of Pinctada fucata (Gould) is in the family Pteriidae. However it was found that several anatomical structures could be of significance taxonomic importance like the anal pappila, typhlosole, nervous system ganglions.

The distribution of the species is mainly in the coralline patches of the coasts of India and the two Oceanic Islands of Lakshadweep andAndaman and Nicobar islands. Morphometrtic characters of pearl oysters collected from different regions of India showed that Gujarat oysters had more depth and thickness though not statistically significant. Ecology of the pearl farm was studied for one year from August 1998 to June 1999 by sampling water both surface and bottom. The results showed that there was no major fluctuation in the water quality except for certain parameters. Gross productivity was correlated with the season with high rates of productivity being shown in the months from November to February in low saline conditions. Seasonal (August 1998 to June 1999), depth wise fouling on farm reared pearl oysters and farm structures were studied by hanging glass panes in shaded and non shaded portions of a pearl oyster raft. The results showed that there was a definite seasonal and depth wise pattern and shade also had an effect. It was observed that barnacles dominated among the fouling organisms. *Balanus amphitrite variegates* was the dominant species of barnacle, *B. vinustus* and *B. tintinnabulum* were occasionally seen. Barnacles peaked in the month of June 1999 and showed a secondary peak in October 1998 and least in the month of May 1999. The fouling was significantly more in the non shaded panels and inversely proportional to the depth.

A positive correlation existed between, months and barnacle fouling while a minor positive correlation existed between clarity, silt with barnacle fouling.

Among the other fouling organisms, the dominant species was hydrozoans. Here also seasonal variations of total weight of fouling organisms revealed that peak settlement was in May 1999 and minimum in October 1998.

Silt also formed a minor fouling substance on both shaded and non shaded panels with two peaks, one in September 1998 and other in June 1999 with peak. The silt load was inversely proportional to depth. The percentage mortality of oysters at these different depths indicated that at 5 m had the lowest mortality. The mortality was directly proportional to the intensity of fouling with the maximum mortality in June 1999 with peak intensity of fouling and none in May 1998 at the highest depth of 5 m.

In the induced maturation experiments, 7.5 ± 3.54%, 6.67% and 15 ±7.07% of fully matured pearl oysters were obtained on day 43, 42 and 36 in oysters fed with mixed algae, (feed 1) mixed algae and corn flour (feed2) mixed algae and rice flour (feed3) respectively in the laboratory conditions, whereas 35% ± 7.07% of fully mature pearl oysters was obtained in the farm (15th day) and in the none in the non fed control respectively.

Studies on the larval rearing of P. fucata showed that the larvae had the typical life history stages like Veliger, Umbo, Eyed, Pediveliger, Plantigrade and Spat stage. The total days required to complete the life cycle was 20-25 days (usually 23 days).

Formation of pearl-sac was observed in the wax nucleus implanted on the gonad of the of the oysters within 3-7 days after implantation in case of 3 mm nuclei, 4-10 days in the case of 4mm nuclei and 6- 12 days in the case of 5 mm nuclei.

The histological studies of implanted graft on day 2 showed the inner epithelial cells was not fully disintegrated while the outer epithelial cells facing the wax nucleus was observed to be slightly proliferating. W hereas the graft tissue on day 4 showed proliferation stage (roundish, acidophilic and larger sickle and spindle shaped) basophilic secretory cells in the sub epithelium.

A thin film of nacreous coating was found deposited on the nucleus within 18 days on a 4 mm wax nucleus. Histological studies of the nacreous pearl-sac epithelium in the male gonad of the pearl oyster showed acidophilic cells in low magnification. In higher magnification the hexagonal crystalline secretion on the wax nucleus, acidophilic secretory cells in the pearl sac epithelium covering the wax nucleus was observed.

Histological studies of the nacreous pearl sac formed on the shell bead nucleus which had produced good and lustrous pearl showed, the presence of more cuboidal, flattened non ciliate epithelial cellsalong with large secretory cells (4-6µm). The cells were similar to the cells of the muscular tissue of the gonad. The haemocytes of the gonad tissue extended into the pearl sac epithelium. The acidophilic secretory cells were more with large granules and the basophilic mucous cells were few and these two types of secretory cells were located within and beneath the pearl-sac epithelium. In case of periostracal pearl sacs, which were produced with the wax nuclei in the laboratory, tall, ciliated columnar epithelial cells (30-35µm) were well distributed. The cells had basal nuclei and small granules. In some parts of the sac projections of 10-15m were seen. Congregations of cells resembling haemocytes were also present in some areas of the epithelium. Basophilic mucous cells with granular inclusions were common Acidophilic cells with large secretory granules were present in some parts of the periostracal pearl sac.

The pearl oyster implanted with 4mm shell bead nucleus and 2mm × 2mm graft has produced good lustrous pearls after 4 months whereas the abnormal pearl sac showed “D” quality pearls.

(Excerpt from the book “Studies on eco-biology of Indian pearl oyster Pinctada fucata (Gould)” authored by T. S. Velayudhan, N. Raman and N. R. Menon (Lambert Academic Publishing, Germany)

Vulnerabilities of Fishery Dependent Livelihoods within Kerala State.

Sachin Pavithran (INDO-MARECLIM fellow, NERCI) and Prof. N. R. Menon (Co-Chairman NERCI, Professor Emeritus, School Of Marine Science, CUSAT, Kochi)

The fisheries sector is confronted with, vulnerable to climate change and variability, fluctuations in marine fisheries resources as well as socio-economic conditions. Accordingly, the aim of this research was to assess and understand how fluctuating fisheries resources, climate induced hazards and socio-economic changes affect fishing communities within Kerala State. In order to achieve this the research work carried out a Participatory Vulnerability Analysis (PVA).

All of the respondents (fishermen, fishermen wives and the students) have observed a change in the abundance and composition of fish species. More juvenile and smaller sized fishes are being caught. The Catch per Unit Effort (CPUE) has decreased while the total fish production has increased.

There are however, some contradictories in the respondent's opinions, as some stated that the changes are not for a particular fish species per se, while others can clearly state which species have increased (i.e. oil sardine - *Sardinella longiceps*) and which have declined (i.e. sharks, skates, rays, karikadi) or even vanished (i.e. catfishes). Oil sardines have been observed to be in abundance. It should be pointed out, though these different observations are also dependent on the area, season, the type of fishing activity (i.e. specific target, gear and craft used) and the respondents' knowledge, till the trends observed in fisheries resources are in agreement with the observation of experts who were consulted during the interviews.

The respondents are all highly dependent on fisheries as the main income source; any changes in fisheries resources will therefore affect their socio-economic conditions.

The majority of the respondents are facing significant financial difficulties due to the decrease in fish yield from marine fishery and the increase in the expenses of necessary fishing equipment/ materials (i.e. nets, oil/kerosene/petrol). Meeting everyday needs are difficult and all of the fisher households take loans, which are difficult to repay and have thus fallen in a debt trap. As the students from KUFOS pointed out there is now an economic collapse. The income they gain is not sufficient for them to save.

(Work done as part of INDOMARECLIM project and published as MSc thesis of Kirstin van Riel "Vulnerability and capacity of fisheries and fishery dependent communities to climate variability and change in Kerala"under the supervision of Prof. N. R. Menon and Dr. Annemarie Groot, submitted to Wageningen University)

Marine Ecosystem studies and Biodiversity Concepts

Ajin A M (INDO-MARECLIM fellow, NERCI) and Prof. N. R. Menon (Co-Chairman NERCI, Professor Emeritus, School Of Marine Science, CUSAT, Kochi)

Biodiversity of intertidal ecosystems along the south west coast of India is being studied by way of routine seasonal sampling covering representative rocky, sandy and muddy beaches along Kerala, south west coast of India. Diversity of macrofauna and the related ecological parameters like sediment texture, sediment organic matter, salinity, wave action, recruitment etc. affecting the diversity are assessed.

The predator-pray relationship between the various macrofaunal assemblages are also looked into (Fig 7(a,b)). Study aims to bring to light the ecological imbalances and associated changes in diversity of the intertidal fauna, which is directly influenced by anthropogenic activities.

Fig. 7(a). Donax incarnatus collected from sandy beach of Muzhuppilangadu (lat. 11^{0}47'47"55"N long.75^0 26'27" E)

Fig. 7(b). Astropecten indicus collected from sandy beach of Muzhuppilangadu (lat. 11^{0}47'47"55"N long.75^0 26'27" E)

Monitoring and modeling of Harmful algal blooms along the South West coast of India

Nashad. M (Nansen Scientific Society Ph.D fellow), Prof. N. R. Menon, Dr. Nandini Menon. N. (NERCI) and Lasse H Pettersson(NERSC)

Work involves in situ data collection from 12 selected stations along the SW coast of India for monthly determination of primary productivity, phytoplankton community structure and associated physico-chemical parameters. Along with this, bio-optical parameters are measured routinely using Satlantic free falling profiler II radio meter. Validation of these primary and secondary data would be done at NERSC,Norway for the development of algorithm. Molecular Taxonomy of bacterial consortium associated with blooms is also attempted. The study aims to have a clear cut idea about the HAB dynamics in the coastal waters off SW coast of India (Fig. 8 and Fig. 9)

Fig.8 Trichodesmium erythraeum

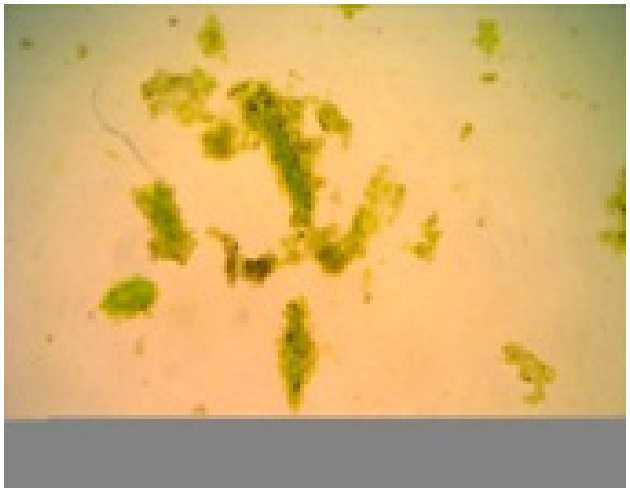


Fig.9 Trichodesmium cells during decay

EVENTS

India - EU Workshop I Marine Primary Production, March2013

Under the auspices of NERCI, an India-EU workshop on ocean primary production was held at Kerala University of Ocean Studies (KUFOS) from March 12 to 15, 2013. This was the first of a planned series of coordinating workshops held by NERCI under the EU INDO- MARECLIM Project. Convenor of the workshop was Prof. Trevor Platt, PML,UK and Co-Convenor was Dr. Nandini Menon, NERCI, India. The meeting was inaugurated by Dr. V. N. Sanjeevan, Director, Centre for Marine Living Resources (CMLRE), Ministry of Earth Sciences, Kochi.

Dr. V. N. Sanjeevan,Director, CMLRE inuagurates the workshop

Other dignitaries who were present, included Prof. B. Madhusoodana Kurup, Vice- chancellor, KUFOS; Prof. Ola M. Johannessen, Founding Chairman of Nansen Scientific Society & Chairman, Steering committee of INDO-MARECLIM; Prof. Trevor Platt, Chairman, POGO, UK & partner of INDO-MARECLIM; Dr. B. Meenakumari, Deputy Director General, ICAR, India; Prof. N. R. Menon, Chair-man, NERCI & Co-ordinator, INDO-MARECLIM; Dr. Shubha Satyendranath, Scientist, PML, UK; Dr. Eddy Moors, Scientist, ALTERRA, the Netherlands and partner, INDO-MARECLIM; Lasse. H. Pettersson, International Director, Nansen center, Norway & Deputy coordinator, INDO-MARECLIM project. The closing ceremonies were graced by the attendance of scientific personalities including Dr. K. Jayasankar, CMFRI, Kochi; Dr. Kanthi Yappa, Sri Lanka; Dr. Beenakumari, Senior scientist, Space Application centre, India. Altogether, around 80 participants including scientists and students from India and EU participated in the workshop. Most of the major Indian institutes working on primary production were rep- resented. The scientific programme had three major elements. First was a series of tutorial lectures on various aspects of measuring primary production, interpreting the results and applying them to questions on biogeochemistry and fisheries. These were delivered by scientists from Europe as well as by Indians. The second element was a set of shorter talks, delivered by Indians and Europeans, intended to survey

the status of primary production studies in Indian waters. The third element was a discussion session aimed at developing the outline of a plan for assessing the primary production of the Indian Ocean. In the discussion sessions, participants considered the possible structure of a plan for regular assessment of primary production in the Indian Ocean.

The experience of organizing a coordination workshop involving scientists from India, as well as scientists from Europe, was highly positive. Excellent discussions were achieved, leading to the outlines of a coordinated plan for the future.

INDO-MARECLIM winter school on climate change and variability, marine ecosystems and coastal zone management, November 2013

One week Winter School was conducted by NERCI under the auspices of INDO-MARECLIM at Bolgatty Palace and Island Resort, Kochi, India from November 2-7 2013. Convener of the workshop was Dr. Nandini Menon, NERCI, India and Co-Convener was Dr. Annette Samuelsen, NERSC, Norway.

Prof. Trevor Platt, Executive Director, POGO,Inaugurating the Winterschool

Participants included PhD students, post doctoral fellows and young scientists from Europe and India. 30 participants from 70 applicants were selected by an expert committee consisting of scientists from the consortium partners. Trainees from UK, Sweden, Croatia, the Netherlands, Norway, Belgium and India participated in the winter school, which was of a truly international character leading to new friendships and academic involvement.

In addition to the lectures delivered by eminent scientists, short practical sessions were conducted. The trainees were divided into 5 groups and each group was assigned a topic on which they were asked to prepare a report based on the literature provided as pre-reads and also by interacting with the resource persons. On the last day of the winter school, each group presented their report which was critically reviewed by the resource persons. Certificates were distributed to the participants. The feedback from the participants helped in evaluating the success of the winter school. All expressed satisfaction in the organization and conduct of the winter school.

India-EU workshop II on Monsoon and ocean variability, climate change and sea level variations

Prof.Ola M.Johannessen, President of Nansen Scientific Society, Norway, inaugurates the workshop

Nansen Environmental Research Centre India (NERCI) organised a three-day workshop as part of the INDO-MARECLIM project to discuss the current status of scientific work on monsoon and ocean variability in the context of global warming and climate change. One of the objectives of the workshop was to explore possibilities for future collaborations among the participants. The workshop conducted at Bolgatty Palace and Island Resort, Kochi, India from November 11 to 13 2013. Convener of the workshop was Prof. P V Joseph, NERCI, India and Co-Convener was Dr. Annalisa Cherchi, CMCC, Italy. The main topics selected for the workshop were:

1) Role of Indian Ocean in Monsoon Variability, 2) Rapid warming of Indian Ocean, and 3) Sea level changes in the Indian Ocean.

During the workshop, aspects of the role of upwelling in the development and intra-seasonal fluctuations of the cold pool of Bay of Bengal, understanding the causes of the rapid warming of the equatorial Indian Ocean, its influence on the Indian summer monsoon and its global teleconnections and change in the sea level particularly over the Indian Ocean were discussed. The workshop hosted 69 participants including 15 from EU countries. There were 12 invited talks and 11 contributed talks from participants.

Publications in 2013

Referred Journals

Abish, B. and K. Mohanakumar, 2013. Absorbing Aerosol Variability over the Indian Subcontinent and its Increasing Dependence on ENSO, Global and Planetary Change Doi: 10.1016/j.gloplacha.2013.02.007

Abish, B., Joseph, P.V. and. Johannessen, O.M., 2013. Weakening Trend of the Tropical Easterly Jetstream of the Boreal Summer Monsoon season 1950 - 2009, Journal of Climate (JCLI- D-13-00440). http://dx.doi.org/10.1175/JCLI-D-13-00440.1

Abish,B. and K. Mohanakumar, 2013. A stochastic model for predicting aerosol optical depth over the north Indian region, International Journal of Remote Sensing, 34, 1449-1458.

Chiranjivi Jayaram, Ajith Joseph K and Balchand A N.,2013. Interannual variability of chlorophyll-a concentration along the southwest coast of India, International Journal of Remote Sensing, Vol. 34(11), 3820-3831.

Joseph P.V., Bindu G., Archana Nair and Shinu S. W., 2013. Variability of Summer Monsoon Rainfall of India on Inter-annual and Decadal time scales. Atmospheric and Oceanic Science Letters, Vol. 6 (5): 398-403, doi:10.3878/ j.issn.1674-2834.13.0044.

Priyalakshmi, G. and Menon, N.R. 2013. Ecology of Interstitial Faunal assemblages from the beaches along the coast of Kerala. International Journal of Oceanography. (In press).

Books & Book Chapters

Abish. B and K. Mohanakumar, 2013. Evidence of aerosol induced alteration of cloud parameters and its impact on the climate system over the Indian subcontinent, Climate Change and Environment, Scientific Publishers, New Delhi. ISBN: 9788172338336.

Abish. B and K. Mohanakumar, 2013. Transport and Distribution of Atmospheric Aerosols over India: A Satellite Perspective. LAP LAMBERT Academic Publishing. ISBN: 9783659398049.

Velayudhan T.S and N.R Menon. 2013. Ecology of Indian Pearl oyster Pinctada fucata (Gould). Scientific text book, Springer-Verlag Pub. ISBN 978-3-659-34920-1.

Conference Proceedings Papers

Arunmozhi, P. Ajith Joseph, K. Ramalingam, M. (2013). Identification of river plumes of Ganga-Brahmaputra-Meghna river basin in the Bay of Bengal using satellite altimetry. IAHS-IAPSO-IASPEI General Assembly 2013, (Poster).

Archana Nair, Joseph, P.V. and U. C Mohanty. 2013. Dry and wet epochs in Indian summer monsoon reainfall and their association with global sea surface temperature anomalies. Proceedings of COSMOS, NPOL, Kochi. 130-135.

Archana Nair and Ajith Joseph, K. 2013. A synthetic supervising approach to improve skill of General Circulation models in summer monsoon season over India. Po-P2-53. Proceedings of CORDEX-International conference on Regional climate to be held from 4-7, November, Brussels.

Harenduprakash L. and K. Ajith Joseph. 2013. Steadiness of 10m winds based on ECMWF ERA Interim daily fields. Proceedings of COSMOS, NPOL, Kochi. 148-151.

Mary Swapna George, Laurent Bertino, Annette Samuelsen, P V Joseph. 2013. Mini Cold Pool formed off the tip of India during the southwest monsoon as seen in a Hybrid coordinate Ocean Model (HYCOM). Proceedings of COSMOS, NPOL, Kochi.86-88.

Shinu Sheela Wilson and P V Joseph. 2013. Teleconnection between anomalous convective heat source over West Pacific ocean and monsoon rainfall of India. INTROMET 2014. SRM University, Chennai., Feb.,2014.

Mary Swapna George, Laurent Bertino, Annette Samuelsen and P V Joseph.2013. Simulation of Cold Pool in the Indian Ocean during the south-west monsoon using a Hybrid Coordinate Ocean Model. Proceedings of National Conference OSICON 2013 "Role of Oceans in Earth System", IITM, Pune, 26-28 November 2013.

Shinu S Wilson and Porathur V Joseph, Difference between El Ninos associated with drought Indian Summer Monsoon and those not associated during 1979 to 2010, OSICON 2013-IITM, Pune,26-28 November 2013.

Participants of India-EU Workshop on Marine Primary production held in March, 2013 at Kochi

INDO-MARECLIM WINTER SCHOOL ON

CLIMATE CHANGE, MARINE ECOSYSTEMS AND COASTAL ZONE MANAGEMENT

2 - 7 NOVEMBER 2013- BOLGATTY, KOCHI, INDIA

NANSEN ENVIRONMENTAL RESEARCH CENTRE (INDIA)

Executive Director: Dr. K. Ajith Joseph
Address: 6A, Oxford Business Centre, Sreekandath Road,
Ravipuram, Ernakulam, Kochi - 682 016, Kerala, INDIA
http://www.nerci.in
Phone: +91-484-2383351/94473-25564 Fax: +91-484-2353124
e-mail: nansencentre.india@gmail.com

A Partner in the **Nansen Group** of research institutes led by Prof. Ola M. Johannessen, also comprising:

Nansen Environmental and Remote Sensing Center Bergen, Norway http:// www.nersc.no

Nansen International Environmental and Remote Sensing Centre St. Petersburg Russia http://www. niersc.spb.ru/

Nansen-Zhu International Research Centre Beijing, China http:// nzc.iap. ac.cn

Nansen-Tutu Centre for Marine Environmental Research Cape Town, South Africa http://mare.uct. ac.za/ nansen- tutu-centre

Nansen- Bangladesh International Centre for Coastal, Ocean and Climate Studies Dhaka, Bangladesh

Nansen Scientific Society Bergen, Norway