2nd International Indian Ocean Expedition 2015-2020

News Letter

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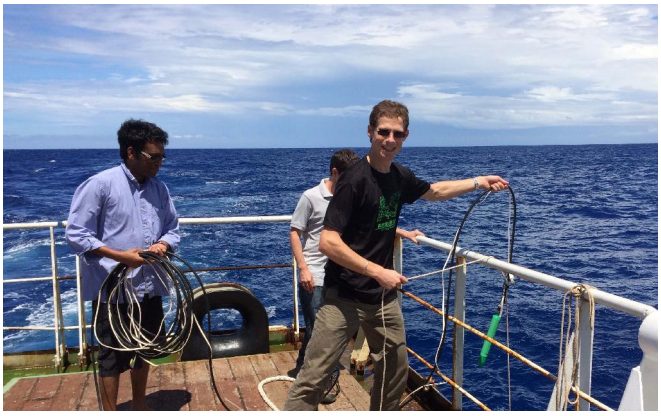
(A basin-wide research program co-sponsored by IOC-UNESCO, SCOR and IOGOOS)

To advance our understanding of interactions between geologic, oceanic and atmospheric processes that give rise to the complex physical dynamics of the Indian Ocean region, and to determine how those dynamics affect climate, extreme events, marine biogeochemical cycles, ecosystems and human populations.

IIOE-2 sheds light on phosphorus cycling in the Indian Ocean

One of the first research papers resulting from an IIOE-2 cruise (http://www.iioe-2.incois.gov.in/IIOE-2/EP01.jsp) has been published in Limnology & Oceanography this year. The study, by Martin et al., reports high rates of alkaline phosphatase activity and evidence for efficient recycling of the important molecule polyphosphate along a transect from India (Goa) to Mauritius.

Alkaline phosphatase is one of the main enzymes that recycle dissolved organic phosphorus in the ocean, and is expressed when phytoplankton have insufficient phosphorus to grow. At most stations along the transect, the dissolved phosphate concentration in the surface mixed layer was below the detection limit of 30 nmol L^{-1}. The results imply a degree of phosphorus scarcity that had hitherto not been recognised in the Indian Ocean. In addition, the authors measured the concentration of polyphosphate, a linear phosphate polymer produced by all organisms that is increasingly recognised as important in the marine phosphorus cycle. Originally, it was thought that marine phytoplankton use polyphosphate just to store excess phosphorus. However, it is now known that phytoplankton actually increase their polyphosphate levels when phosphorus is extremely scarce. This paradoxical observation is likely because polyphosphate plays an essential role in the microbial response to nutritional stress. However, polyphosphate concentrations along the Indian Ocean transect were similar to regions with high dissolved phosphate concentrations. This indicates that phytoplankton experience less phosphorus stress in the Indian Ocean than in other regions such as the subtropical North Atlantic.



Collecting additional water samples for biogeochemical measurements from the surface layer using a battery-operated pump

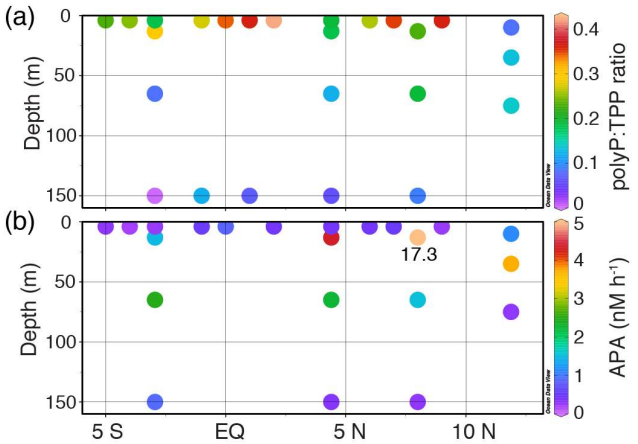


Figure: (a) The ratio of polyphosphate to total phosphorus in particulate matter decreased strongly with depth throughout the transect, indicating that polyphosphate was recycled at shallow depths. (b) Alkaline phosphatase activity was found at all depths, and at relatively high rates (always ≥ 0.18 nmol P/L/h, and always > 1.0 nmol P/L/h between 10 m and 65 m depth).

The authors speculate that monsoonal changes in the supply of iron and macronutrients along the transect are the reason why dissolved phosphate was drawn down to sufficiently low levels to trigger alkaline phosphatase activity, but without reaching the extreme levels of phosphorus scarcity found in the subtropical North Atlantic.

Previous studies had reached conflicting conclusions about the biogeochemistry of polyphosphate, with some

evidence suggesting that polyphosphate is very rapidly recycled at shallow depths, but other evidence suggesting that polyphosphate is actually buried in sediments. In the Indian Ocean, Martin et al. found a strong decrease with depth in the polyphosphate content of particles relative to total particulate phosphorus concentrations, which indicates preferential recycling of polyphosphate. Comparing these results to previous studies suggests that polyphosphate biogeochemistry in the ocean is controlled by alkaline phosphatase, with polyphosphate recycling observed in regions of high alkaline phosphatase activity, but not in the absence of alkaline phosphatase. Overall, the new study suggests that the unique monsoonal current patterns in the Indian Ocean lead to sufficient phosphorus depletion that widespread alkaline phosphatase expression is triggered, causing polyphosphate recycling, but without resulting in the extreme polyphosphate accumulation by phytoplankton seen in parts of the North Atlantic.

[Martin, P., Lauro, F. M., Sarkar, A., Goodkin, N., Prakash, S., Vinayachandran, P. N.,2018, Particulate polyphosphate and alkaline phosphatase activity across a latitudinal transect in the tropical Indian Ocean, Limnology and Oceanography, doi: 10.1002/lno.10780]

[Report and photos courtesy: Patrick Martin, Nanyang Technological University, Singapore; pmartin@ntu.edu.sg]

The vertical distribution of planktonic gastropods: new results from IIOE-2

Understanding the vertical distribution of aragonite shelled planktonic gastropods is essential when considering the effects of imminent ocean acidification and climate change. It has long been hypothesised that the planktonic aragonite shelled atlantid heteropodsreside in the upper 250 m of the ocean. However, this is a very broad definition of their habitat, where exactly do they live? A new study published in Marine Ecology Progress Series by Wall-Palmer et al. addresses this question.

Young adult atlantid heteropod Oxygyrus inflatus collected in the Atlantic Ocean during cruise AMT27. Maximum shell diameter (excluding keel) 1.6 mm.

Previous studies using opening and closing plankton nets have given us snippets of information about vertical distributions. However, these are often restricted to a small geographic region, or to only a few species. We took a different approach, using a combination of museum collections to look at broad distributions and migration patterns, and shell geochemistry, to pin point exactly where shells are calcified.

Species collection data (species, depth, time) was collated from publications and from several museum collections, including specimens collected during SN105, the first oceanographic cruise of IIOE-2 (http://www.iioe-2.incois.gov.in/IIOE-2/EP01.jsp). This revealed two patterns of atlantid heteropod vertical migration. Small species remained in shallow waters of < 140 m at all times, whereas larger atlantids migrated to deep waters during the day, returning to shallow waters at night. The data revealed that some atlantids probably migrate to even deeper waters than we anticipated (>600 m), highlighting that the atlantids may be affected by a shallowing aragonite lysocline in addition to surface water acidification.

To look closer at the depth of shell calcification, oxygen isotope ratios of atlantid shells from the Atlantic Ocean, the Red Sea, and specimens collected during the IIOE-2 cruise SN105 in the Indian Ocean were calculated. When atlantids produce their shells they incorporate oxygen and carbon (and many other elements) from the water in which they live, trapping a chemical signature of the water within their shells. We used this chemical signature, in addition to water temperature and salinity, to determine the depth at which the atlantids calcified their shells.

The data revealed that calcification takes place within the upper 150 m of the water column for all 16 of the species analysed. This depth is linked to concentration of chlorophyll (algae) in the water and is likely a region of abundant food.

Atlantids are carnivorous, but their planktonic prey feed on algae and will have high numbers where there is abundant chlorophyll. This region is projected to experience the earliest and greatest anthropogenic ocean changes, strongly indicating that atlantid heteropods will be adversely affected in the near future.

[Wall-Palmer, D., Metcalfe, B., Leng, M. J., Sloane, H. J., Ganssen, G., Vinayachandran, P. N., Smart, C. W., 2018, Vertical distribution and diurnal migration of atlantid heteropods, Mar Ecol Prog Ser.,587:1–15. https://doi.org/10.3354/meps12464*]*

[Report courtesy: Deborah Wall-Palmer, Naturalis Biodiversity Center, the Netherlands; dmwallpalmer@gmail.com]

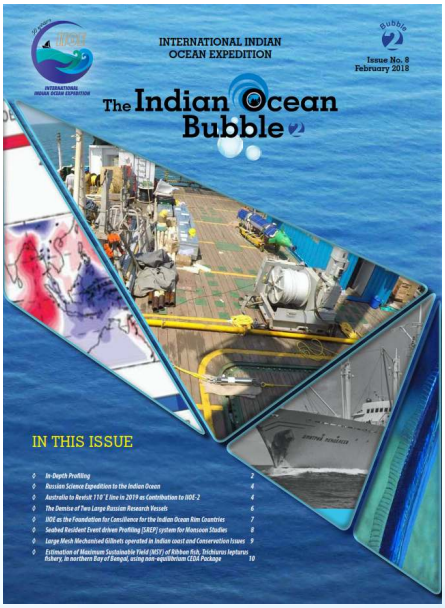
Diane Erceg joins IOC PPO as the New Programme Manager

Dr. Diane Erceg has joined the IOC-Perth Programme Office (IOC PPO) as the new Programme Manager from 12 February, 2018. She is employed by the Australian Bureau of Meteorology (BoM) and 80% of her duties are generously assigned by BoM to support the IOC PPO as Program Manager. Diane replaces Dr. Romola Stewart, who has moved on to an international position with WWF based in Perth. We thank and wish Romola our best, whilst also warmly welcoming Diane.

Diane studied across environmental science, policy and history. She has a professional background in international management of environment, science and tourism with a regional focus on Antarctica and the Southern Ocean. Diane's roles since 2003 have included: acting as a National Delegate to the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR); working in the Secretariat of the Agreement on the Conservation of Albatrosses and Petrels (ACAP) and as Chief Rapporteur in the Secretariat for Antarctic Treaty Consultative Meetings (ATCM). In 2004, she was a member of the SURVOSTRAL (Surveillance de l'Ocean Austral) oceanographic cruise, monitoring heat content, surface salinity, hydrology and circulation of the Southern Ocean between Tasmania and Adélie Land, Antarctica. Diane's experience during 2005-14 also included eight summer seasons working as an expedition guide and multi-disciplinary lecturer on Antarctic tourist expeditions. Diane has recently completed her PhD thesis on the history of Antarctic tourism, culminating in a book on the subject that is currently in preparation.

Diane will support the IOC PPO across its full portfolio of activities, including the IOC PPO's responsibilities as a node of the Joint Project Office for IIOE-2. E-mail: diane.erceg@bom.gov.au

The Indian Ocean Bubble, Issue No. 8 is now available online



Web Link: http://www.iioe-2.incois.gov.in/IIOE-2/pdfviewer_pub.jsp?docname=IIOE-2-DOC_OM_97.pdf

Call for Contributions

Informal articles are invited for the next issue. Contributions referring Indian Ocean studies, cruises, conferences, workshops etc. are welcome.

Articles may be up to 1500 words in length (Word files) accompanied by suitable figures, photos (separate .jpg files)

Deadline: **31st May, 2018**

Send your contributions as usual to **iioe@incois.gov.in**

Some Upcoming Events

- The Second face-to-face meeting of the IIOE-2 Steering Committee is scheduled to be held along with the Annual Meetings of Indian Ocean Global Ocean Observing System Regional Alliance (IOGOOS), Indian Ocean Region Panel (IORP), Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) and Indian Ocean Observing System Resources Forum (IRF) during 19-23 March 2018. The meetings will be hosted by LIPI and BMKG of the Government of Indonesia in concert with UNESCO IOC Perth Programme Office and will take place at the Grand Mercure, Kemayoran, Jakarta.

  Registrations are now open via the link International Indian Ocean Science Conference 2018

  Watch out for further details on the IIOE-2 website: www.iioe-2.incois.gov.in

- "The Indian Ocean's past, present and future", Session at the European Geosciences Union (EGU) General Assembly, Vienna, Austria, 08-13 April 2018. http://meetingorganizer.copernicus.org/EGU2018/session/26749

- A Session on "The Eastern Indian ocean Upwelling Research Initiative (EIOURI) and the Second International Indian Ocean Expedition" at the 15th Annual Meeting of the Asia Oceania Geosciences Society, Honolulu, Hawaii, 03-08 June 2018. http://www.asiaoceania.org/aogs2018/public.asp?page=home.htm

- CLIVAR-FIO Joint Summer School on 'Past, Present and Future Sea Level Changes' and the UNESCO/IOC ODC Training Course on 'Ocean Forecast Systems', at Qingdao, China, from June 25 - 30, 2018 and July 2-7, 2018 respectively. http://www.clivar.org or http://www.fio.org.cn/en/training_center/index.htm

Endorse your projects in IIOE-2

Don't miss the opportunity to network, collaborate, flesh out your research project and participate in IIOE-2 cruises!!

Over 27 international, multi-disciplinary scientific projects have already been endorsed to date by the IIOE-2. Yours could be the next one!

Visit http://www.iioe-2.incois.gov.in/IIOE-2/EndorsementForm.jsp for further details and for projects already endorsed by IIOE-2.

The Indian Ocean Bubble-2

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IOGOOS Global Ocean Observing System for Indian Ocean

UNESCO United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

SCOR International Council for Science Scientific Committee on Oceanic Research