U.S. Committee for IIOE-2

2nd International Indian Ocean Expedition

U.S. IIOE-2 Newsletter #1
December 2016

Welcome to the first edition of the U.S. IIOE-2 Newsletter! The purpose of this communication is to keep the U.S. community of experts involved in Indian Ocean research informed about scientific activities of their U.S. colleagues and to provide the latest news about international IIOE-2 activities. Please contact Raleigh Hood at the University of Maryland (*rhood@umces.edu*) if you have questions or comments, or wish to communicate about your recent, current, or upcoming research activities in the Indian Ocean via this newsletter. Articles in future issues should be a maximum of 500 words and include one figure.

News from U.S. Committee for IIOE-2

A committee of ocean scientists with an interest in Indian Ocean research has formed under Raleigh Hood of the Univ. of Maryland. The membership includes individuals from several institutions around the United States who have been active in Indian Ocean research. The overarching goal of this committee is to promote U.S. involvement in the 2nd International Indian Ocean Expedition. For more information, see the U.S. IIOE-2 Web site (*http://www.us-iioe2.org*).

The committee has been meeting quarterly by teleconference since early Fall 2015. Most of the committee members met in person on 25 February 2016 in conjunction with the Ocean Sciences meeting in New Orleans, Louisiana. Among other things, it was decided at the meeting to continue to seek funding for a workshop to coordinate existing research and plan new research. Toward this end, the committee has submitted an interdisciplinary workshop proposal to U.S. CLIVAR and the OCB program to identify U.S. research priorities in the Indian Ocean. Other decisions were to continue to broaden the email list of U.S. scientists who have been or currently are involved in scientific activities in the Indian Ocean, and to create a newsletter to inform the community about developments related to U.S. participation in Indian Ocean research.

U.S. IIOE-2 Web site

A Web site has been developed to keep U.S. investigators informed about the status of U.S. involvement in the IIOE-2. As mentioned above, the Web site can be found at *http://www.us-iioe2.org*. We welcome suggestions for making the site more useful to the U.S. community. The Web site includes links to the IIOE-2 Science Plan and Implementation Strategy, as well as the list of known cruises and other activities.

The IIOE-2 Joint Project Office node in India has set up an informative Web site at *http://www.iioe-2.incois.gov.in/IIOE-2/index.jsp*

Members are featured at the end of the newsletter.

U.S. Science Activities in the Indian Ocean

The IIOE-2 Science Plan and Implementation Strategy

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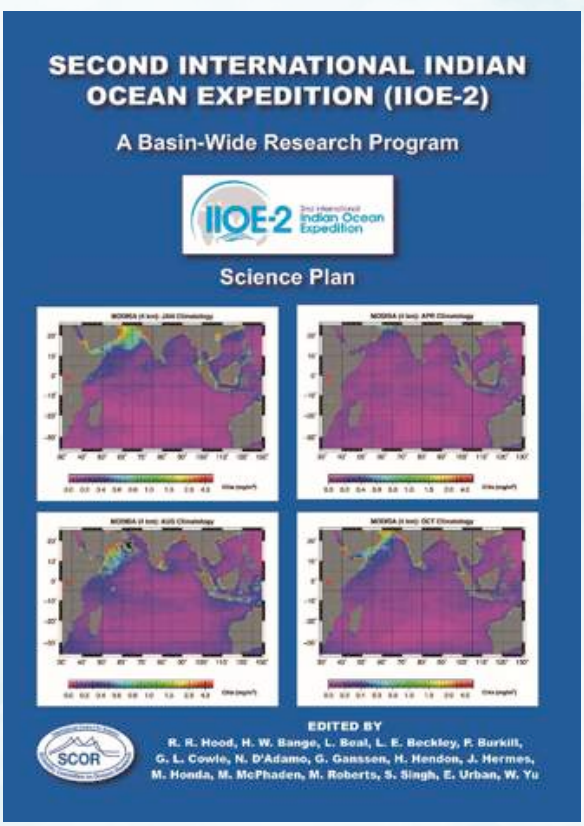
Introduction

The end of 2015 marked the 50th Anniversary of the completion of one of the greatest oceanographic expeditions of all time: the International Indian Ocean Expedition (IIOE).

In the 50 years since the IIOE, fundamental changes have taken place in studies of geology, oceanography, and atmospheric sciences. These changes have revolutionized our ability to measure, model, and understand the Earth System. SCOR (Scientific Committee on Oceanic Research), IOC (Intergovernmental Oceanographic Commission) and IOGOOS (Indian Ocean Global Ocean Observing System) are working together to stimulate a new phase of coordinated international research focused on the Indian Ocean for a 5-year period that began in late 2015 and will continue through 2020. The goal is to organize ongoing research and stimulate new initiatives within this period as part of a larger expedition. These activities will serve as a core for a new Indian Ocean research focus, which has been dubbed "IIOE-2."

The IIOE-2 Science Plan



An IIOE-2 Science Plan has been developed with the sponsorship of SCOR (Hood et al., 2015). The overarching goal of the IIOE-2 is to advance our understanding of interactions among 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. The IIOE-2 Science Plan is structured around six scientific themes. Each of these themes include a set of questions that need to be addressed in order to improve our understanding of the physical forcing that drives variability in marine biogeochemical cycles, ecosystems and fisheries in the Indian Ocean and to develop the capacity to predict how this variability will impact human populations in the future. It is also important to emphasize that most of these questions are relevant to open-ocean, coastal, and marginal sea environments.

Theme 1: Human Impacts

(How are human-induced ocean stressors impacting the biogeochemistry and ecology of the Indian Ocean? How, in turn, are these impacts affecting human populations?)

Theme 2: Boundary current dynamics, upwelling variability and ecosystem impacts

(How are marine biogeochemical cycles, ecosystem processes and fisheries in the Indian Ocean influenced by boundary currents, eddies and upwelling? How does the interaction between local and remote forcing influence these currents and upwelling variability in the Indian Ocean? How have these processes and their influence on local weather and climate changed in the past and how will they change in the future?)

Theme 3: Monsoon variability and ecosystem response

(What factors control present, past and future monsoon variability? How does this variability impact ocean physics, chemistry and biogeochemistry in the Indian Ocean? What are the effects on ecosystems, fisheries and human populations?)

Theme 4: Circulation, climate variability and change

(How has the atmospheric and oceanic circulation of the Indian Ocean changed in the past and how will it change in the future? How do these changes relate to topography and connectivity with the Pacific, Atlantic and Southern oceans? What impact does this have on biological productivity and fisheries?)

Theme 5: Extreme events and their impacts on ecosystems and human populations

(How do extreme events in the Indian Ocean impact coastal and open-ocean ecosystems? How will climate change impact the frequency and/or severity of extreme weather and oceanic events, such as tropical cyclones and tsunamis in the Indian Ocean? What are the threats of extreme weather events, volcanic eruptions, tsunamis, combined with sea level rise, to human populations in low-lying coastal zones and small island nations of the Indian Ocean region?)

Theme 6: Unique geological, physical, biogeochemical, and ecological features of the Indian Ocean

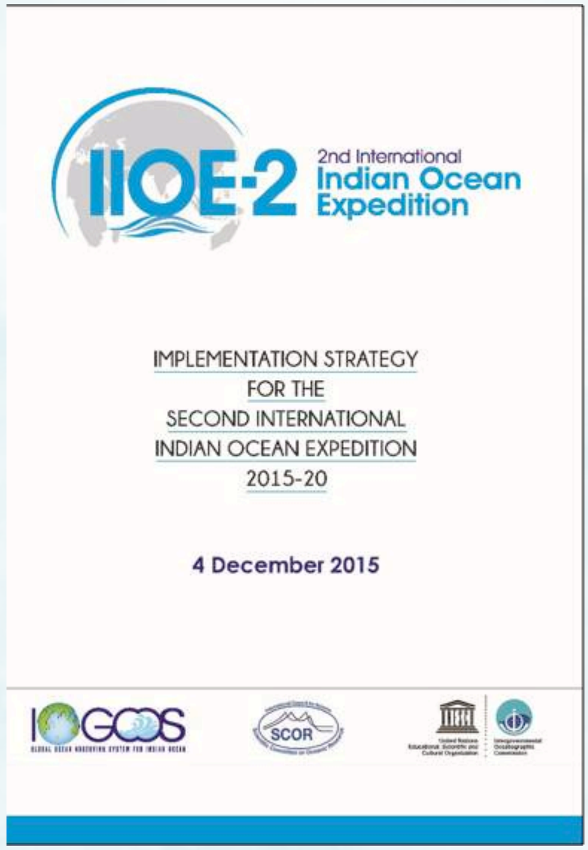
(What processes control the present, past, and future carbon and oxygen dynamics of the Indian Ocean and how do they impact biogeochemical cycles and ecosystem dynamics? How do the physical characteristics of the southern Indian Ocean gyre system influence the biogeochemistry and ecology of the Indian Ocean? How do the complex tectonic and geologic processes, and topography of the Indian Ocean influence circulation, mixing and chemistry and therefore also biogeochemical and ecological processes?)

The IIOE-2 Science Plan is highly interdisciplinary, encompassing geologic, atmospheric and oceanographic research from coastal environments to the deep sea and trophic levels ranging from microbes and phytoplankton to top predators, including fish and humans. The IIOE-2 Science Plan identifies important scientific questions for consideration as potential research foci for national and international studies in the Indian Ocean, while also recognizing the coastal and regional interests of many Indian Ocean rim countries that seek to pursue research as part of IIOE-2.

IIOE-2 Research Initiatives

In addition to coordinating ongoing research, the IIOE-2 is working to initiate new research projects and programs that are designed to address the core IIOE-2 research themes. These include both national and international efforts. For example, international efforts are underway to initiate upwelling research initiatives in both the eastern and western Indian Ocean: the Eastern Indian Ocean Upwelling Research Initiative (EIOURI, Yu et al., 2015) and the Western Indian Ocean Upwelling Research Initiative (WIOURI). These new initiatives, which are aligned with CLIVAR's interdisciplinary upwelling research theme, are focused on understanding the interacting forces that drive upwelling variability in the Indian Ocean and the resulting biogeochemical and ecological responses.

The IIOE-2 Implementation Strategy


IIOE-2 2nd International Indian Ocean Expedition

IMPLEMENTATION STRATEGY
FOR THE
SECOND INTERNATIONAL
INDIAN OCEAN EXPEDITION
2015-20

4 December 2015

An Implementation Strategy for the IIOE-2 has been developed with the sponsorship of IOC (IPC, 2015). The major sections of the Implementation Strategy cover the structure of the IIOE-2 Steering Committee, its associated governance, its elemental membership and the functions of seven Working Groups to be formed under it. These working groups include Science and Research, Data and Information Management, Capacity Development, Operational Coordination, Outreach and Communication, Translating Science for Society, and Resourcing and Sponsorship. The Joint Project Office, currently established with two nodes, in Australia and India, is also addressed in terms of its structure and functions, and its role in organizing sustained sponsorship and resourcing support for the Expedition.

The Implementation Strategy places a strong emphasis on ensuring that the IIOE-2 is efficiently and professionally run, administered, and resourced. Another key emphasis is ensuring that the science to be undertaken is of contemporary relevance, of a high standard and is integrated within the thematic elements of the IIOE-2 Science Plan. Priority is also given to ensuring that the data and information that emerges from the Expedition is properly managed. Another key aspiration is to leave a lasting legacy throughout the Indian Ocean region, as did the original IIOE, by establishing the basis for improved scientific knowledge transfer to wider segments of society and regional governments, and to enable educational and capacity development opportunities in support of regional and early-career scientists. The IIOE-2 Science Plan and Implementation Strategy can be downloaded from the IIOE-2 website: *http://www.iioe-2.incois.gov.in.*

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The Indian Ocean Subseafloor Microbial Habitat

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The seafloor and subseafloor in the Indian Ocean harbor diverse potential microbial habitats, offering opportunities for new scientific discoveries. Deep basins and trenches, culminating in the 7,450 meter-deep Sunda Trench; fracture zones; hotspots and ridges with hydrothermal activity; seamounts; subduction zones; and coastal margins all occur within relatively close proximity in this youngest of Earth's oceans. Two oceanic gyres, large riverine nutrient inputs, and transient monsoonal high productivity drive spatial gradients in nutrients and salinity that likely impact seafloor microbial diversity. Many novel cultured organisms have been isolated from subseafloor sediments in the Indian Ocean. However, much of the in situ microbial communities are comprised of types of organisms that are resistant to culturing efforts (Khandeparker et al., 2014). Therefore, culture-independent approaches and novel culturing techniques hold great promise for expanding our understanding of this region.

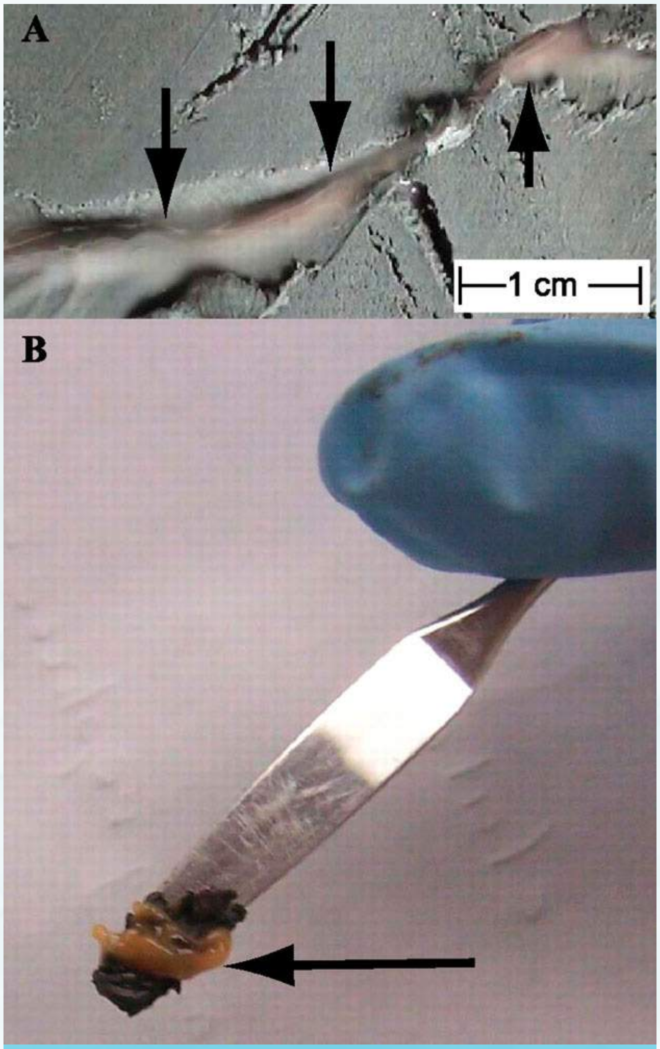

Figure 1. Photograph of a biofilm collected from a fracture in the Indian Ocean at 19 m below the seafloor. Arrows point to the orange biomass. (A) Biofilm within the fracture before sampling; (B) biofilm that has been scraped out of the fracture using a spatula. The spatula blade is approximately 2 cm long. Reproduced with permission from the American Society for Microbiology.

Culture-independent work has shown that the diverse environments in the Indian Ocean drive microbial community diversity (Wu et al., 2011). Similar work focusing on specific environmental types has resulted in many new discoveries. Methane seeps in the Sumatra forearc sediment basin contain methane- and sulfur-cycling communities that likely impact the emission of hydrocarbon and sulfur compounds from these nearshore sediments (Schippers et al., 2010; Siegert et al., 2011). Microbial communities associated with methane hydrates, or clathrates, in deep subseafloor sediments in the Andaman Sea appear to be distinct from those found at other hydrate environments worldwide (Briggs et al., 2012). Intriguingly, subseafloor sediments from the Krishna-Godavari and Mahanadi Basins have been shown to contain pink and orange mats of microbes associated with anaerobic methane oxidation (Briggs et al., 2011; Figure 1). Such a high biomass of anaerobic methane oxidizers has only ever been reported in Black Sea mats, which have essentially launched a field of intense study of the process (Michaelis et al., 2002). The discovery of a second site where such samples may be retrieved is extremely valuable.

These surveys depended largely on DNA sequences of the microbial taxonomic marker gene 16S. However, accessing genomic data to examine microbial functional diversity is essential for understanding the in situ functions of uncultured microbes (Solden et al., 2016). Perhaps future work will include such data, to provide the first glimpses into the functions of microbes in situ in the various Indian Ocean subseafloor environments.

Perhaps the most exciting recent work in the Indian Ocean is the International Ocean Discovery Program Leg 360 to the Southwest Indian Ridge from November 2015 to January 2016. Microbiologists Virginia Edgcomb and Jason Sylvan were on board, and were able to obtain some of the first deep subsurface microbial samples from the Indian Ocean. As they process their samples and analyze their data back on land, they are certain to make some wonderful discoveries.

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GEOTRACES in the Indian Ocean

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GEOTRACES is an international program that seeks to improve our understanding of the biogeochemical cycles and large-scale distributions of trace elements and isotopes (TEIs) in the world's oceans (*www.geotraces.org*). Although the elemental coverage in GEOTRACES is broad, essentially most of the Periodic Table, there is a set of "key" TEIs central to the program, including aluminum, cadmium, copper, iron, lead and its isotopes, neodymium isotopes, 230Th, and zinc. To date, chemical oceanographers from more than 35 nations have been involved in the GEOTRACES program, which is designed to study all major ocean basins over the next ten years, including the Indian Ocean. These studies utilize two field sampling modes: ocean basin transects and location-specific process studies. Figure 2 shows the already completed (in yellow) and planned (red) GEOTRACES transects in the Indian as of June 2016.

The first GEOTRACES transect cruise to the Indian Ocean was the 2009 Japanese-led occupation of the GI04 line (Figure 2) that produced exciting iron data from hydrothermal inputs at the Triple Junction (Nishioka et al., 2013). Discussions are currently ongoing about re-occupying this line. Transect cruises by Indian scientists occupied the GI01, GI02, and GI03 lines from 2012 to 2014. There are several plans to conduct the very long GI05 transect, as well as the GI06 cruise, in the next three years. These cruises would be conducted by a combination of German, French, and perhaps Australian ships. The southern Indian Ocean transects GI07 and -08 will likely be led by Australia. It should be noted that U.S. GEOTRACES has made no plans for sampling the Indian Ocean. Several GEOTRACES process cruises have been conducted since 2010, with the Indian-led ones focusing on the northern-most areas of the basin, while Australia has conducted several process cruises in the southern Indian near Antarctica. Many more of these process cruises around the basin are planned.

Overall, the GEOTRACES program has or will have a reasonable coverage of the Indian Ocean basin. In this respect, it is important to note that GEOTRACES is not just TEI-focused, but collects GO-SHIP-quality hydrography and nutrients, as well other tracer/mixing parameters such as CFCs, and carbon system parameters, on all cruises to meet program data requirements. Thus, GEOTRACES transects and process studies can provide important geochemical and tracer data for the IIOE-2 program.

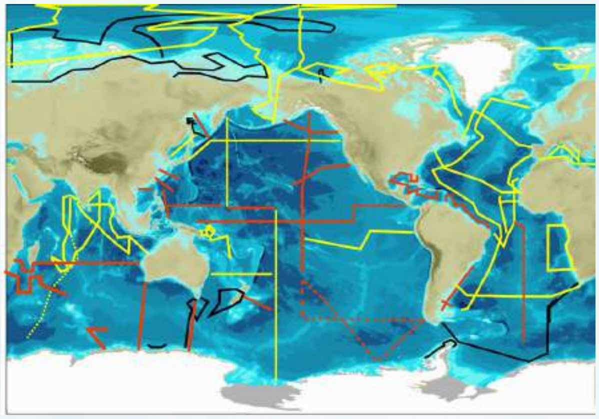

Figure 2. GEOTRACES transect cruises in the Indian Ocean, with those in yellow being completed and the ones in red being planned. This figure doesn't include any of the more than ten planned or executed process studies in the Indian Ocean.

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The Arabian Sea – an ecosystem in transition

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Of the many anthropogenic and climate-driven changes being reported in oceanic ecosystems worldwide, the Arabian Sea stands out as one that is experiencing the most dramatic and extreme changes of all. Within a decade and a half, the Arabian Sea has experienced a radical shift in the composition of winter blooms from those dominated by diatoms to thick and widespread blooms of *Noctiluca scintillans*. As a large (>600µm) green mixotrophic dinoflagellate that can sustain itself by photosynthesis from its free-swimming endosymbionts and ingestion of exogenous prey (Fig. 3a), *Noctiluca* competes for resources with both its prey and predators. Its recent and rapid advent as the dominant organism at the base of the food chain has raised the specter of an ecosystem that is in transition (Goes and Gomes, 2016). Evidence from field studies, limited immensely by the Arabian Sea's piracy problems, have attributed outbreaks of *Noctiluca* blooms to expansion of the oxygen minimum zone and the spread of hypoxia (Gomes et al., 2014). Over the past few years, blooms of *Noctiluca* have become particularly intense and widespread off the coast of Oman (Figs, 3b-c) and increasingly problematic for coastal fisheries, tourism, aquaculture, as well as for the operation of

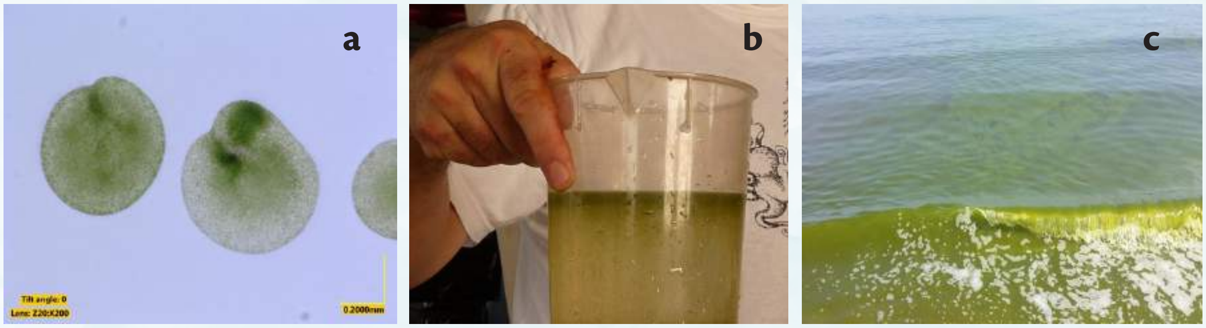

Figure 3: Noctiluca ***bloom sample under a microscope showing individual*** Noctiluca ***cells, b) Bucket sample transferred to a glass beaker shows thickness of bloom, c) Blooms as seen from the ship-deck. (photographs – Joaquim Goes)***

Noctiluca bloom outbreaks are also disruptive for the operations of oil refineries, which depend on a continuous supply of seawater for cooling (Azri et al., 2013; Al-Hashimi et al., 2014).

An enigmatic aspect of *Noctiluca* blooms during winter is their ability to grow and proliferate for almost 3 months as thick and widespread blooms, a phenomenon attributed in part to the absence of grazing pressure by typical zooplankton of the Arabian Sea food chain (Gomes et al., 2014). *Noctiluca* are also able to grow faster than most zooplankton, and hence are able to outcompete other organisms as predators on phytoplankton. The largest consumers of *Noctiluca* are salps (Figs. 4a-b) but the appearance of salps in the euphotic zone is rather sporadic (Gomes et al., 2014).

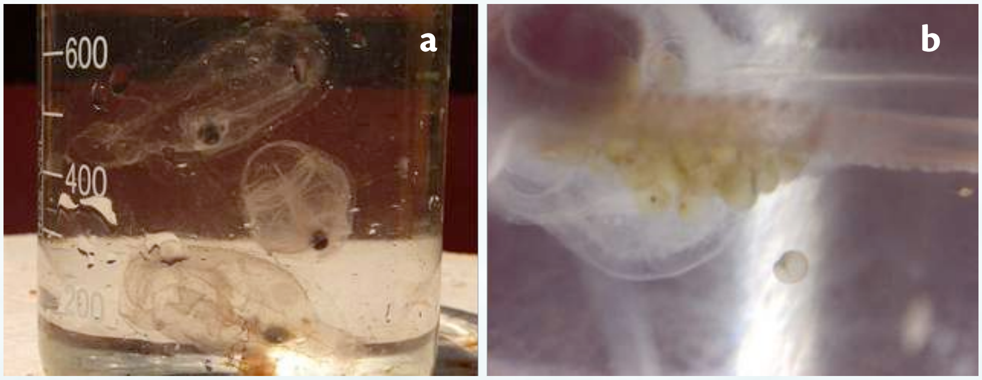

Figure 4: a) Salps the primary grazers of Noctiluca*, b) Stereo-microscopic close up of* Noctiluca *cells within the guts of salps – photograph credits Joaquim Goes and Ed Buskey)*

The survival of *Noctiluca* over prolonged periods demands a sustained supply of nutrients. In winter, the convective mixing that is the primary mechanism for nutrient influxes into the euphotic zone has been steadily weakening over the past 10 years (Gomes et al., 2014), suggesting that *Noctiluca* blooms possibly rely on alternate sources of nutrients, one being aerosol dust plumes (Figs. 5a-b). In the Arabian Sea, most aerosols are crustal in origin and therefore are a rich source of trace metals (Chester et al., 1991). Although it is known that aerosols are capable of transporting a range of nutrients—including nitrogen, phosphorous and trace metals (Wiggert et al., 2006)—, little is known whether dust storms are a source of nutrients for *Noctiluca* blooms. The importance of atmospheric deposition versus nutrient influxes via winter convective mixing and mesoscale eddy activity is a topic worthy of future research.

Another interesting aspect of *Noctiluca* blooms is their relationship to hypoxia. Oxygen deficiency (< 4µM) is a unique feature of the northeastern Arabian Sea, but a characteristic of deeper depths (>120m –1500m) (Naqvi et al., 1997; Morrison al., 1999). The formation of the oxygen minimum zone (OMZ) has been linked to a combination of factors: high surface productivity of semi-annual phytoplankton blooms, the low dissolved O2 (DO) containing sub-thermocline source waters flowing from the Southern Ocean, and poor ventilation of subsurface waters in the landlocked northern part of the Arabian Sea. In all likelihood, the appearance of O2-deficient waters in the euphotic zone suggests that the permanent OMZ is expanding, but the rate at which this process is taking place and the relative influences of processes such as enhanced summer productivity, stratification and changes in circulation patterns, human activities etc., demand further examination, especially because *Noctiluca* could very well represent a bellwether organism in tropical marine ecosystems experiencing environmental changes (enhanced stratification and hypoxia) associated with global warming. Obtaining answers to several unknowns about *Noctiluca* blooms, including its impact on the carbon cycle of the Arabian Sea, will require detailed studies on the ecology and physiology of the cells and their relationship with their green endosymbionts, in order to accurately assess the long-term impacts of *Noctiluca* blooms on the food chain, on carbon cycling and fisheries, as the Arabian Sea ecosystem becomes increasingly vulnerable to environmental variability and climate change.

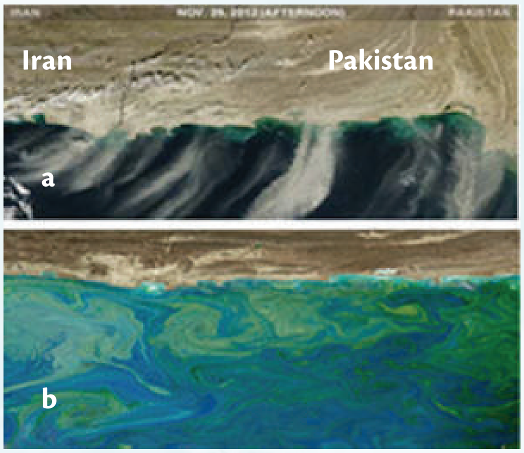

Figure 5: a) Noctiluca *blooms of Feb. 2013 associated with b) large and persistent aeolian dust plumes off the coasts of Iran and Pakistan which are the result of northeast monsoon winds from the Indian-subcontinent, Iran and Oman (Images courtesy Norman Kuring (NASA, GSFC)).*

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Project SloMo – Drilling through the Crust to the Moho in the Indian Ocean

Henry Dick

Woods Hole Oceanographic Institution & Christopher MacLeod, Cardiff University (Co-Chief Scientists), Peter Blum, Texas A&M University (Staff scientist), and the Expedition 360 Scientific Party.

International Ocean Discovery Program (IODP) Expedition 360 drilled 790 m into a tectonically exposed lower crustal gabbro massif at Atlantis Bank on the SW Indian Ocean Ridge at Site U1473 (57°E, 32°S) in December 2015 and January 2016 (Figure 6). This was followed by a short remediation leg, Expedition 362T, in July 2016 that deepened the Hole to 809.5 m below seafloor and cemented it to preserve it for future reoccupation. Expedition 360 was the beginning of 'Project SloMo', a multiphase drilling project that seeks to drill through the crust-mantle boundary, and ultimately through the Mohorovicic discontinuity (Moho) located ~5 km below Atlantis Bank. It is anticipated that the drill ship JOIDES Resolution will return in two to three years to further deepen Hole U1473A, with the ultimate goal of drilling through the crust-mantle boundary (expected to be shallower than the Moho), ending Phase I of the Project (Figure 7). Phase II would drill through the Moho itself, probably utilizing the deep-riser drillship Chikyu. SloMo represents a revival of Project Mohole which, after initial successes in demonstrating the feasibility of scientific drilling in the oceans, terminated in 1966 by the U.S. Congress due to very high projected costs. The new project, however, capitalizes on existing technology and facilities, which make drilling to the Moho possible at far less cost. In addition, it capitalizes on drilling at a location where the highly fractured and difficult-to-drill upper 1-2 km of the crust has been tectonically removed, and uplifted to 700 m water depth, where it is far more efficient to drill.

Previous drilling at Atlantis Bank on ODP Legs 118, 176 and 179 drilled two other holes, 1508-m deep Hole 735B in 1987 and 1997, and 158-m deep Hole 1105A in 1997. The former hole was a first attempt to drill through the crust that ended with a pipe failure that permanently blocked the hole, whereas the latter was drilled serendipitously on an engineering leg. Together with Hole U1473A, these holes constitute the first (~2 km) lateral transit across a large gabbro massif representing ~125,000 years of accretion of the lower crust at a slow-spreading ridge. The cores recovered from these holes demonstrate that the section formed via an interplay of tectonic and magmatic processes that generated what was a relatively homogeneous crust overall. On a finer scale, however, the section is internally quite heterogeneous, representing the end-product of a complex set of processes of solid-state, and near solid-state crystal-plastic deformation, periodic intrusion of melt, and late-stage melt percolation through the lower crust, coupled to late brittle faulting and hydrothermal circulation of seawater into the lower crust as it was uplifted and exposed on the seafloor.

Scientific ocean drilling at Atlantis Bank has transformed our understanding of accretion of the oceanic lower crust, disproving the old paradigm that it represents the fossil remains of giant magma chambers such as are seen in layered intrusions on land (e.g., Stillwater, Bushveldt and Skaergaard Intrusions), once again validating Alfred Wegner's statement that when the ocean crust was finally explored, it would be nothing like the continental crust, contrary to common wisdom at the time.

Hole U1473A is a magnet site that will bring scientific drillships back to the Indian Ocean in the near future, possibly in the 2019 time frame, and opens up the opportunity for additional drilling in the southern Indian Ocean and African Margin. This offers a window for new proposals for sediment and hard rock drilling to be submitted to the International Ocean Discovery Program in time for scheduling in that time frame.

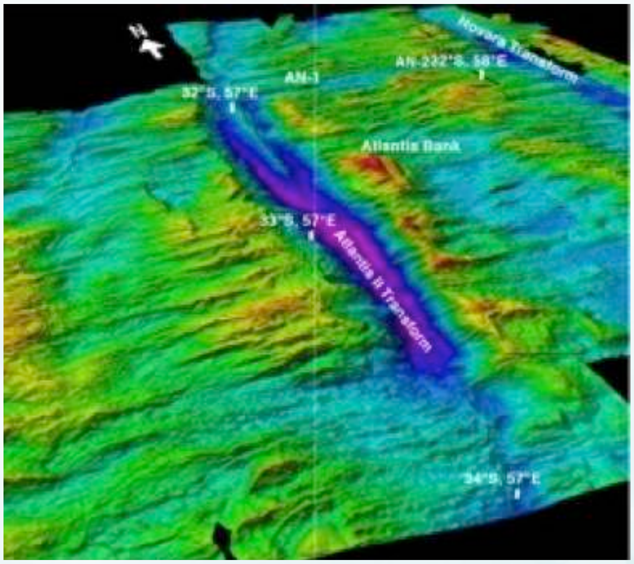

Figure 6: Shaded seafloor bathymetry map showing the SW Indian Ridge and the location of Atlantis Bank where IODP Hole 1473A is located

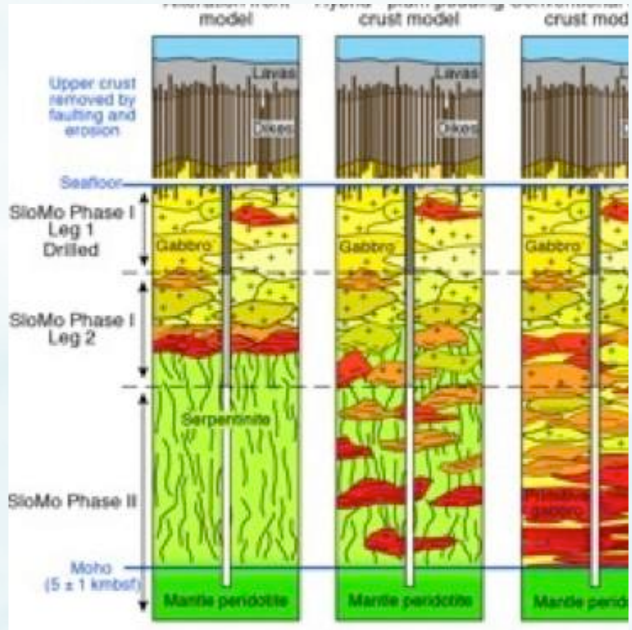

Figure 7: Possible options for the crust-mantle boundary at Site 1473 on Atlantis Bank.

U.S. Cruises in the Indian Ocean and Endorsement of Projects

An international database of cruises is available at *http://www.iioe-2.incois.gov.in/IIOE-2/Expedition*.jsp (see link at bottom of page). This list includes activities that are planned, funded, and ongoing. We encourage U.S. scientists to contact other cruise PIs directly to explore opportunities for cooperation in research activities.

We also encourage U.S. scientists to seek endorsement of their research projects. An endorsement form is available at *http://www.iioe-2.incois.gov.in/IIOE-2/EndorsementForm.jsp*.

Please inform Ed Urban (*ed.urban@scor-int.org*) if any information in the table needs to be corrected or if additional activities need to be added to the table.

U.S. Cruises and Other Activities in the Indian Ocean

Title	Status	Period	PI	PI email	Keywords
	Planned	2015 - 2018	Dan Rudnick	drudnick@ucsd.edu	gliders, profiling floats, seasonal, interannual, circulation
	Planned	2016	Henry Dick	hdick@whoi.edu	Marion Rise, SW Indian Ridge
	Planned	2015 – 2017	Jim Moffett, Bess Ward, Wajih Naqvi	jmoffett@usc.edu	nitrous oxide, hot spots, OMZ, dentrification
Noctiluca blooms in the sea of Oman	Ongoing	2014 to 2018	Joaquim Goes	jig@ldeo.columbia.edu	satellite algorithms, environmental controls, *Noctiluca* blooms
Climate variability and Hilsa fisheries	Ongoing	2017 to 2018	Indrani Pal Helga Gomes Joaquim Goes	helga@ldeo.columbia.edu	monsoon influence, ecosystem processes, Bay of Bengal
SOCCOM	Funded	2015-2020	Jorge Sarmiento, Lynne Talley, Steve Riser, Ken Johnson, Emmanuel Boss	ltalley@ucsd.edu	bio-Argo, nitrate, pH, oxygen, fluorometer, backscatter
	Funded	2015 – 2020 and beyond	Lynne Talley, Gregory C. Johnson, Richard A. Feely	Gregory.C.Johnson@noaa.gov	US GO-SHIP
RAMA Array	Ongoing	2015 - 2020	Mike McPhaden	michael.j.mcphaden@noaa.gov	RAMA, monsoon analysis, prediction, African-Asian-Australian Monsoon, Research Moored Array
Masirah Island time-series	Ongoing		Sharon Smith	sharon.smith@rsmas.miami.edu	temperature, phytoplankton species' abundances and zooplankton species' abundances
GO-SHIP IO7 (north)	Planned	2018	Gregory Johnson Lynne Talley	gregory.c.johnson@noaa.gov ltalley@ucsd.edu	heat, freshwater, carbon, oxygen, nutrients and transient tracers
GO-SHIP IO6	Planned	2019	Gregory Johnson Lynne Talley	gregory.c.johnson@noaa.gov ltalley@ucsd.edu	heat, freshwater, carbon, oxygen, nutrients and transient tracers
GO-SHIP IO5	Planned	2020	Gregory Johnson Lynne Talley	gregory.c.johnson@noaa.gov ltalley@ucsd.edu	heat, freshwater, carbon, oxygen, nutrients and transient tracers
Atmospheric Forcing and the Structure and Evolution of the Upper Ocean in the Bay of Bengal	Ongoing	Until March 2018	John T. Farrar, Robert A. Weller	jfarrar@whoi.edu	Bay of Bengal, air-sea interactions
Arabian Sea Fronts and Barrier Layers	Ongoing	Until March 2018	Andrey Shcherbina	ashcherbina@apl.washington.edu	upper-ocean dynamics, Arabian Sea, monsoons, regional climate
SST Control by Subsurface Mixing during Indian Ocean Monsoons	Ongoing	Until 31 January 2018	Emily Shroyer, James Moum	eshroyer@coas.oregonstate.edu moum@coas.oregonstate.edu	Bay of Bengal, turbulent mixing,SST
Observations of Local Seychelles Circulation	Ongoing	Obs. through June 2017; the project will continue through the end of 2018.	Geno Pawlak	pawlak@ucsd.edu	Seychelles Islands, circulation, observations, modeling
Northern Arabian Sea Circulation - Autonomous Research: Optimal Planning Systems (NASCar-OPS)	Ongoing	To 2019	Pierre F.J. Lermusiaux	pierrel@mit.edu	autonomous observing, ocean circulation, mixed layer
Coastal Ocean Sensing and Forecasting for Fisheries Management: Practical Systems for India	Ongoing	At least through 2017	Pierre F.J. Lermusiaux	pierrel@mit.edu	physical and biogeochemical forecasting, coastal fisheries management
Quantifying Boundary Currents in the Arabian Sea	Ongoing	through Sept. 2018	Janet Sprintall	jsprintall@ucsd.edu	Arabian Sea, western boundary currents, monsoon winds
Monsoon Variability in the Arabian Sea from Global 0.08-degree HYCOM Simulations	Ongoing		Julie L. McClean	jmcclean@ucsd.edu	ocean general circulation models, Arabian Sea dynamics, Somali Current

U.S. Committee for IIOE-2


Raleigh Hood (Chair, University of Maryland, biological oceanography)


Dwi Susanto (University of Maryland, physical oceanography)


Lisa Beal (University of Miami, RSMAS, physical oceanography)


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Lynne Talley (Scripps Institution of Oceanography, physical oceanography)


Greg Cutter (Old Dominion University, chemical oceanography)


Mike Landry (Scripps Institution of Oceanography, biological oceanography)


Chidong Zhang (NOAA, PMEL, atmospheric science)


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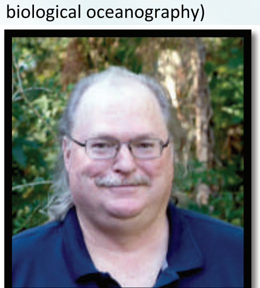
Joaquim Goes (Columbia University, LDEO, biological oceanography and satellite oceanography)


Karen Lloyd (University of Tennessee Knoxville, deep-sea microbiology)


Jerry Wiggert (University of Southern Mississippi, interdisciplinary modeling)


Henry Dick (Woods Hole Oceanographic Institution, marine geology and geophysics)