

Cruise Plan

10th Southern Ocean Expedition (2017 - 2018)



National Centre for Antarctic and Ocean Research (NCAOR)

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Multidisciplinary studies in the Indian Ocean sector of Southern Ocean:

Background:

The Southern Ocean (SO) is a very challenging region compared to other oceans for accomplishing any scientific investigation due to its harsh climate inaccessibility and remoteness. A drastic heat and mass transport is occurring across Antarctic Circumpolar Current (ACC). Hence understanding this current system has a major role in the climatic variability studies. SO is the site for deep and intermediate water mixing and hence provides the principal link between the upper and lower layers of the global ocean circulation. As a result, the SO strongly influences the Earth's climatic patterns and the cycling of carbon and nutrients. The SO plays a major role in the climate system, and is recognized as the oceanic body most sensitive to climate change. Changes in the SO would therefore have global ramifications. Low resolution and incomplete nature of existing sea-truth data often makes the causes and consequences of observed changes difficult to assess. Therefore sustained and multi-disciplinary observations are required to detect, interpret and respond to the changes in the Southern Ocean. SO is a major sink for atmospheric CO₂, and its role in global carbon budget is highly significant since the atmospheric CO₂ is increasing, which leads to the global warming. Even though the SO acts as a major sink for atmospheric CO₂, it is also one of the few areas where macronutrients are underutilized (presumably due to the limitation of biological productivity by low dissolved micronutrients and less availability of solar radiation) by phytoplankton making it a high-nutrient, low-chlorophyll (HNLC) area. There are several oceanic fronts across the ACC such as Sub-Tropical fronts (STF), Agulhas Retroflexion Front (ARF), Sub-Antarctic front (SAF), Polar Front (PF), Southern Antarctic Circumpolar Current Front (SACCF); Southern Boundary of ACC (SB) and Antarctic Slope Front (ASF) where water characteristic changes swiftly. The diverse spatiotemporal biogeochemical characteristics of these fronts are need to be addressed time to time for understanding the role of SO in global ocean biogeochemistry. One of the essential components of a systematic study is time-series observation, which is extremely important to give better insight in understanding the processes that are under the combined influence of physical, chemical and biological controls. Time series observation particularly at frontal regions are therefore interesting since these are marked by intense physical mixing of the different water masses which will have pronounced influence on the distribution of nutrients, trace metals and hence the overall productivity.

The Indian Ocean sector of SO is a region remains under-investigated where the data available are sparse which impede our knowledge to understand the role of SO in the climatic va-

riabilities. Availability of long term sea truth data from this area is imperative for understanding the various processes affecting the climate so as to evolve suitable mitigating measures. Therefore, large-scale, detailed, multiship, synoptic and time series sea truth observations of this region deserve highest priority. In this scenario Ministry of Earth Sciences [MoES] and NCAOR have been initiated a long-term internationally coordinated programme for planning and executing the research activities in the Indian Ocean sector of SO (Region between 40S and 69S and 45E and 80E). To date, nine multi-disciplinary and multi-institutional cruises have been successfully implemented during the austral summer of 2004, 2006, 2009, 2010, 2011, 2012, 2013, 2015 and 2017 by NCAOR as the nodal agency involving about a dozen leading institutions and Universities. The focus areas of research in the Southern Ocean realm include air-sea interaction, physical processes, biogeochemistry, palaeo-climate etc. Significant findings have been made from the previous SO expeditions [SOE] which have been throwing new light in our understanding of the various physical and biogeochemical processes that are responsible in modulating the global warming and climate variability. Based on which more than 60 papers were published in the national and international journals. Special issues in Current Science and Deep Sea Research II also have been published in November 2010 and August 2015 respectively.

Objectives:

The SO research programme is mainly focusing on the “*Role and response of Southern Ocean to the regional and global climate variability*”. Previous SOEs (2004-2017) have attempted to understand the spatial and temporal variability of different fronts as well as the coastal processes in the Indian Ocean sector of the SO based on the hydrographic data collected along various transects between 40°E and 80°E. Last four year’s SOE (2011-12, 2012-13, 2014-15 & 2016-17) mainly focused on the Subtropical Front (STF) to Polar Front (PF) and in the Prydz Bay (PB) region [coastal waters of Antarctica near India’s third station, Bharathi]. Detailed studies on air-sea interaction, hydrodynamics, food web dynamics and biogeochemistry were carried out in the above regions of the Indian Ocean sector of SO. A set of mooring equipments like current meters, micro-cats and sediment traps have been deployed in the STF region during SOE 2016-17 for a comprehensive understanding of the seasonal and inter-annual variability of the physical, biological and geological parameters of this dynamic regime.

During the SO expedition 2017, detailed observations were made in the PB region during austral summer, however in the SO expedition 2017-18 it is planned to deploy an under-ice mooring for a period of one year. This time series observations are significant to understand the seasonal variabilities in the dynamics and biochemical processes of the coastal waters of

Bharathi station as well as its impact on this ecosystem. Considering the global carbon cycle the region between the PF and coastal waters of Antarctica, the Antarctic Zone (AZ), is an important as well as very dynamic marine ecosystem, which encompasses a complex food-web dynamics (Sarmiento et al., 1998; Takahashi et al., 2002, Gloersen et al., 1992; Whitworth et al., 1998; Bindoff et al., 2000;; Williams et al., 2008 & 2010). Hence detailed observations are planned to be carried out to understand the dynamic physical changes due to the various forces like influence of bottom topography, wind stress, mesoscale variability, cross-zonal exchange of water masses, vertical density stratification, and SAM - ENSO etc. Influence of various physical and chemical processes on the phytoplankton, zooplankton and microbial niche in the AZ also will be studied to understand the complexities of the food web dynamics within this region. Due to discrete and few data points in the AZ, it is unclear that how the biogeochemistry, food web dynamics and physical processes in the AZ behave, and this needs to be addressed further to understand the role of SO in global climate change.

Towards achieving these goals, consequently, the 10th SOE to the Indian Ocean sector of the SO will be launched in early December 2017 to have a comprehensive study in the region southwards of 40°S, between PF and PB as well as with an under ice mooring in the coastal waters of the Bharati station (69°S 76°E). The samplings during this expedition will be made for physical chemical, biological and geological studies with the following focal scientific themes.

1. Atmospheric sciences
2. Water column dynamics
3. Biogeochemistry
4. Foodweb dynamics
5. Palaeoclimatic studies

Studies on atmospheric sciences will be mainly concentrated on *aerosol studies, wind stress, momentum flux, vertical atmospheric structure etc.*

The water column dynamics studies include *i) Thermohaline structure in the AZ with special reference to understand the source of fresh water and water masses characteristics - bottom water (AABW originating from Cape Darnley) iii) Heat budget variability iv) Current variability and v) Relate physical forcing with biological production*

The studies on biogeochemistry in the AZ shall be concentrated on *i) ¹⁴C-based primary production ii) ¹⁵N-enriched primary production iii) Measurements of bio-optical parameters*

iv) *Phytoplankton biomass* v) *Macro-nutrients dynamics* iii) *Microbial uptake rates of organic carbon* iv) *Organic carbon inventory (TOC, POC, carbohydrates) and* v) *pCO₂ measurement* vi) *Si accumulation and cycling in Southern Ocean.*

The major components which will be addressed in the Food web dynamics are i) *Phytoplankton diversities through taxonomic studies* ii) *Phytoplankton diagnostic pigment studies through HPLC* iii) *Micro- and meso-zooplankton standing stock, diversity and migration* iv) *Zooplankton productivity* v) *Evaluation of proximate biochemical composition of major zooplankton groups* and vi) *Distribution of microbial biomass.* Collection of sediment core at coastal area of Antarctica for diatom and dinoflagellates cyst analysis

Plaeoclimatic studies: Southern Hemisphere Annular Mode's (SAM) impacts on modulation of the Indian Ocean SST are attributed to the tele-connection between south Asian Monsoon and the South Pole. *A solid paleoclimate record encompassing past SST from the Polar waters as well as progressively north of it will be highly directive to address the tropical - polar tele-connection.* In this quest, in the tenth Southern-Ocean Expedition it is planned to acquire necessary marine samples in the form of water samples as well as sediment core from desired latitudes.

References

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- Takahashi T., Sutherland S. C., Sweeney C., Poisson A., Metzl N., Tilbrook B., Bates N., Wanninkhof R., Feely R. A., Sabine C., Olafsson J. & Nojiri Y. 2002. Global sea-air CO₂ flux based on climatological surface ocean pCO₂, and seasonal biological and temperature effect. *Deep Sea Research Part II* 49, 1601-1622.
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Research proposals relevant to the above focal themes are invited from research organizations, universities and other institutions engaged in R&D activities. The cruise track for the expedition is attached. The PIs, while proposing their research plan, may make sure to indicate the type of samples required, the exact sampling location and facilities/equipments required for collection, analysis and storage. It may be noted that no deviation from the objectives as well as sampling strategies will be allowed as this would hamper the progress of the expedition. It is desirable that the PI/Co-PI may participate in the expedition along with the team. The names of participants and their designation may be indicated in the proposal. The proposal in the enclosed format may be send on or before **10th July, 2017** to,

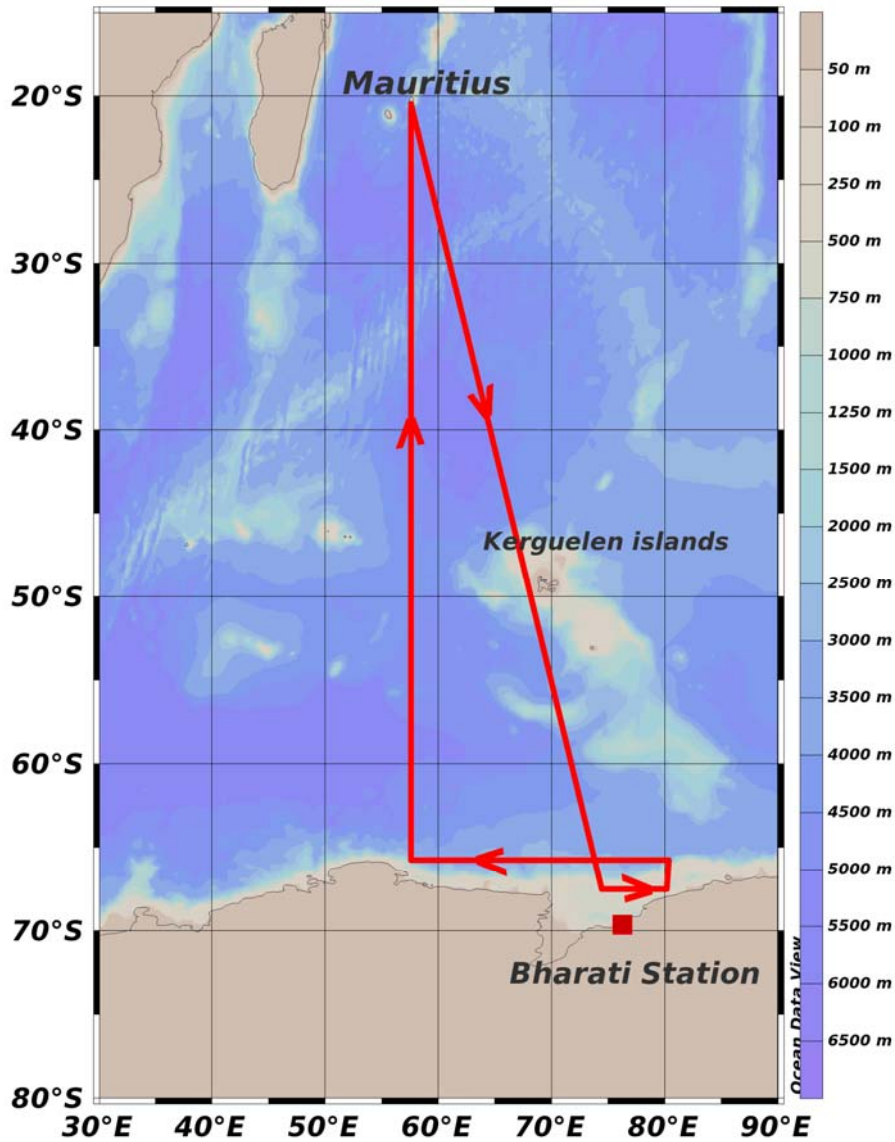
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With a copy to,

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The proposals will be reviewed by an expert committee constituted by Director, NCAOR and the PI will be intimated the date for presentation of the research proposal to this expert committee sufficiently in advance. It is requested that PIs who have participated in the

previous SO expedition may also present the results of their study at the time of project presentation. It is also suggested that those who have participated in the earlier expedition and if interested to participate in SOE 2017-18, may submit a proposal as a continuation of the studies carried out by them in the earlier SO expedition.



Tentative cruise track for SOE 2017-18