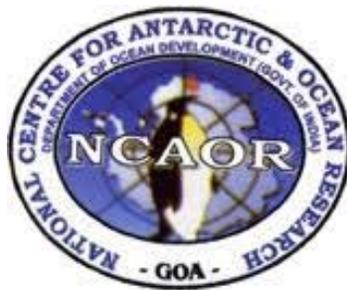


Cruise Plan

(ORV - Sagar Nidhi)

9th Southern Ocean Expedition (2015 - 2016)



National Centre for Antarctic and Ocean Research (NCAOR)

Headland Sada, Vasco-da-Gama, Goa-403804, India

Multidisciplinary studies in the Indian Ocean sector of Southern Ocean:

Background:

The Southern Ocean (SO) is the southern most part of the world ocean and physically links the major ocean basins. 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.

Recent concern about the increasing levels of atmospheric CO₂, thus global warming has led to the studies of the Southern Ocean's role in global carbon budget. 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. The SO is characterized by several oceanic frontal systems and zones such as Agulhas retroflection front (ARF); Subtropical Frontal Zone (STZ); Subtropical Fronts (STF); Subantarctic Frontal Zone (SAZ), Subantarctic Front (SAF), Polar Frontal Zone (PFZ), Polar Front (PF); Antarctic Zone (AZ); Southern Antarctic Circumpolar Current Front (SACCF); Southern Boundary of ACC (SB) and Antarctic Slope Front (ASF) where rapid changes in water properties occurs. These fronts have distinct spatiotemporal biogeochemical characteristics, which needs to be addressed time to time for understanding the role of SO in global ocean biogeochemistry.

Studies in the Indian Ocean sector of the SO are scanty as seen from existing literature. Thus more systematic scientific investigations need to be conducted for a comprehensive understanding of the physical and biogeochemical changes occurring in this part of the global ocean. 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 National Centre for Antarctic and Ocean Research (NCAOR) is the nodal organization

for planning, coordinating and executing multidisciplinary research programmes related to the Southern Ocean Expedition (SOE). The inception of SOE programme was marked by the Indian pilot expedition to SO, which was launched by NCAOR in January 2004. So far, eight SOE have been carried out during the austral summer of 2006, 2009, 2010, 2011, 2012, 2013 and 2015 by NCAOR as the nodal agency involving several leading research institutions/universities in the country to understand the complexities of the Indian sector of the SO. These efforts of Indian scientists on SO oceanography have yielded valuable data, 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.

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 (2004-2015) have attempted to understand the spatial and temporal variability of different fronts in the Indian Ocean sector of the SO based on the hydrographic data collected along the meridional sections (48°E and 57° 30'E). Last three year's SOE (2011-12, 2012-13 & 2014-15) mainly focused on the Subtropical Front (STF) and Polar Front (PF). Detailed studies of food web dynamics and biogeochemistry were carried out in the Indian Ocean sector of the STF & PF.

The Antarctic Zone (AZ) of the Southern Ocean lies between the Polar Front and coastal waters of Antarctica is host to a marine ecosystem and is an important region contributing to the global carbon cycle (Sarmiento et al., 1998; Takahashi et al., 2002). Sea-ice formation, ocean circulation patterns and formation of distinct water masses makes the AZ a physically dynamic region (Gloersen et al., 1992; Whitworth et al., 1998; Bindoff et al., 2000;; Williams et al., 2008 & 2010). AZ receives highly productive Antarctic coastal waters from the south and HNLC waters from the north, resulting in sporadic blooms and high biomass. Recent studies on biological aspects from the Indian Ocean sector have revealed the possibility of existence of contrasting food web dynamics in this area. Therefore it is necessary to make an in-depth study on the phytoplankton, zooplankton and microbial niches in the Antarctic Zone to understand the food web dynamics within this region. Besides that, it is observed that the location and dynamics of AZ are influenced by several physical processes such as (i) bottom topography, (ii) wind stress, (iii) mesoscale variability, (iv) cross-zonal exchange of water masses, (v) vertical density stratification, (vi) SAM and (vii) ENSO. Due to discrete and few data points in the AZ, the previous expeditions could not explain these complex processes. Thus, for a prospective study on the dynamics of AZ there is a need for high resolution (zonal and meridional) atmospheric, physical, chemical and biological data. Only with such comprehensive in-situ data sets, the major processes in the AZ can be described precisely.

Earlier studies have some major findings such as (1) identification of northern PF (PF1) and southern PF (PF2), (2) inter-annual migration of the PF during austral summer and (3) contrasting chlorophyll *a* distribution within the PF. However, it is unclear that how the biogeochemistry, food web dynamics and physical processes in the AZ behave, and this needs to be addressed to further understand the role of SO in global climate change. Towards achieving these goals, therefore, the 9th SOE to the Indian Ocean sector of the SO will be launched in December 2015 to have a comprehensive study in the AZ with special reference to the coastal waters of the India's third Antarctic station Bharati (69°S 76°E). The forthcoming expedition will include a meridional transects and a zonal transects within the AZ (See the cruise track). The samplings during this expedition will be restricted only to water column and atmospheric parameters with the following focal scientific themes.

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

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

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

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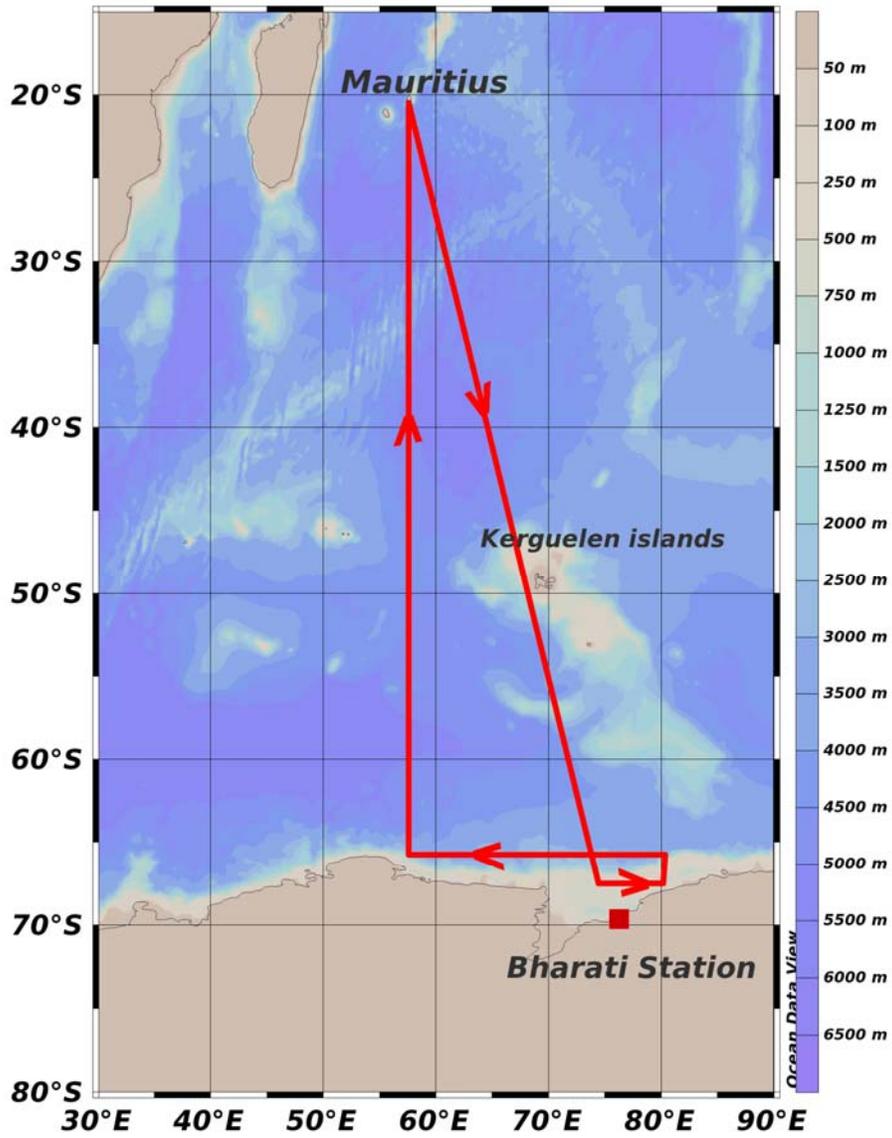
Research proposals relevant to the above focal themes are invited from research organizations, universities and other institutions engaged in R&D activities. The cruise track for the expedition is attached. The PIs, while proposing their research plan, may make sure to indicate the type of samples required, 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, 2015** to,

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With a copy to,

The Director,
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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 2015-16, may submit a proposal as a continuation of the studies carried out by them in the earlier SO expedition.



Tentative cruise track for SOE 2015-16