Cruise Plan

(*ORV - Sagar Nidhi*)

8th Southern Ocean Expedition (2013 - 2014)

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 CO_2, 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 CO_2, 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.

In order to understand the processes that are involved in modulating the climate variability in a regional as well as global scale and its implications on the living resources and biogeochemical cycles, the Ministry of Earth Sciences initiated a long-term nationally coordinated programme with the National Centre for Antarctic and Ocean Research as the nodal agency for planning and executing the research activities. This has resulted in 7 well planned expeditions, the first one being the Pilot Expedition during January-March 2004, which was followed by six more expeditions during the austral summer of 2006, 2009, 2010, 2011, 2012 and 2013. A number of leading research institutions/universities have been actively involved in this programme and regularly participating in the expeditions and carrying out research in unraveling the complexities and mysteries of the Indian Ocean sector of the Southern Ocean.

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 (2004-2011) 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 two year's SOE (2011-12 & 2012-13) mainly focused on the Subtropical Front and Polar Front. Detailed study of food web dynamics and biogeochemistry was carried out in the Indian Ocean sector of the STF & PF.

The Antarctic Zone (AZ) (Figure - 1) 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 8th SOE to the Indian Ocean sector of the SO will be launched in December 2013 to have a comprehensive study in the AZ. The forthcoming expedition will include a meridional transects and a zonal transects within the AZ (See Figure 1 & 2). 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) *^{14}C-based primary production ii) ^{15}N-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) $_{P}CO_2$ 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*.

References

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Whitworth III T., Orsi A., Kim S.-J. & Nowlin Jr W. 1998. Water masses and mixing near the Antarctic Slope Front. In: Jacobs, S., Weiss, R. (Eds.), Ocean, Ice and Atmosphere: Interactions at the Antarctic Continental Margin. American Geophysical Union, Washington, pp. 1–27.

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 **20th July, 2013** to,

Dr. N. Anilkumar,
Scientist 'E' & Coordinator, Southern Ocean Programme,
National Centre for Antarctic & Ocean Research,
(Ministry of Earth Sciences)
Headland Sada, Vasco-da-Gama,
Goa. 403 804
Phone: 0832-2525512/513
Fax : 0832 2525512
E-mail: anil@ncaor.gov.in; anilncaor@gmail.com

With a copy to,

The Director,
National Centre for Antarctic & Ocean Research,
(Ministry of Earth Sciences)
Headland Sada, Vasco-da-Gama,
Goa. 403 804
Tel: 0832-2525503
Fax: 0832-2520877
E-mail: director@ncaor.giov.in

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 2013, may submit a proposal as a continuation of the studies carried out by them in the earlier SO expedition.

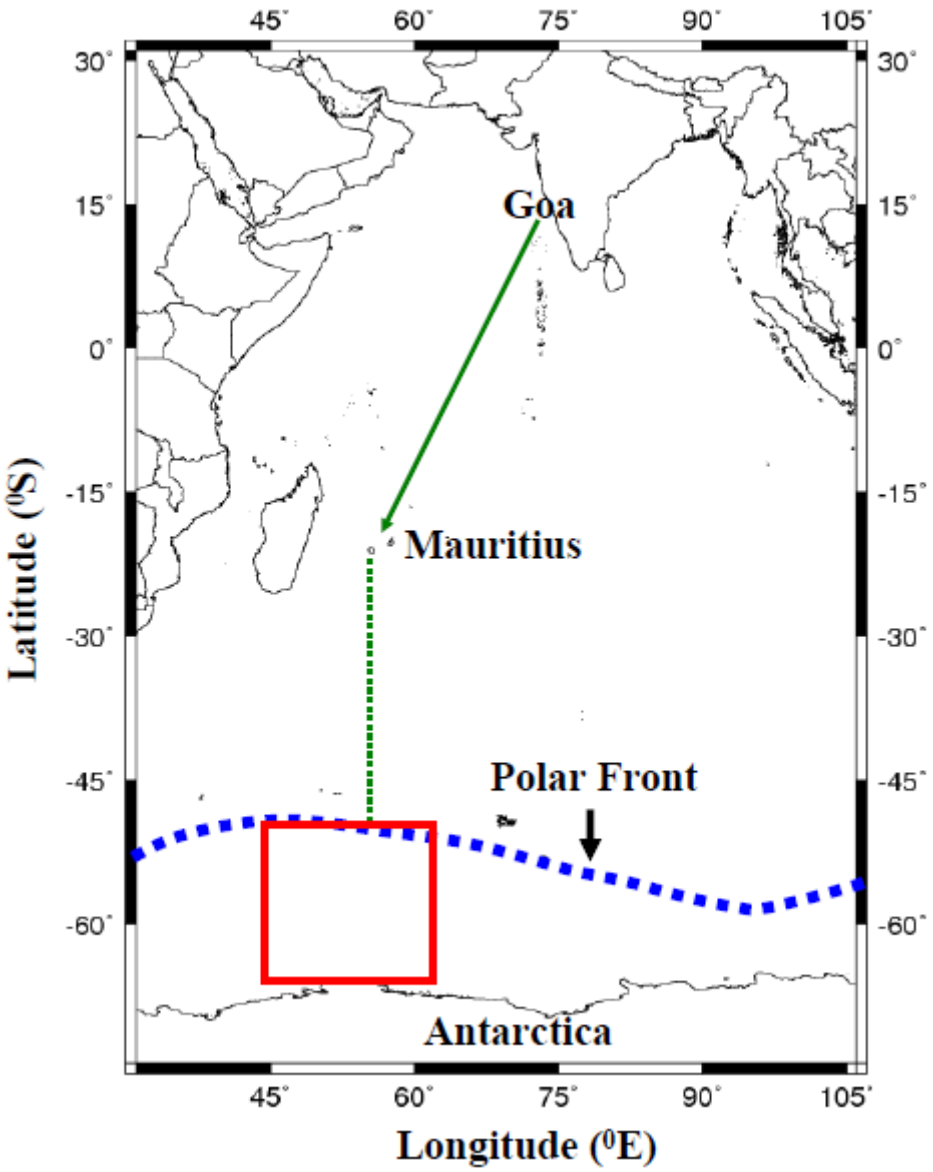

Figure 1: Study area (red box) for SOE 2013-14. Observations shall be carried out in the 48 °E and 57° 30 ′E line at every 1-2° interval till the Polar Front (PF). Intensive sampling will be carried out in the Antarctic Zone (between PF and coastal Antarctica).

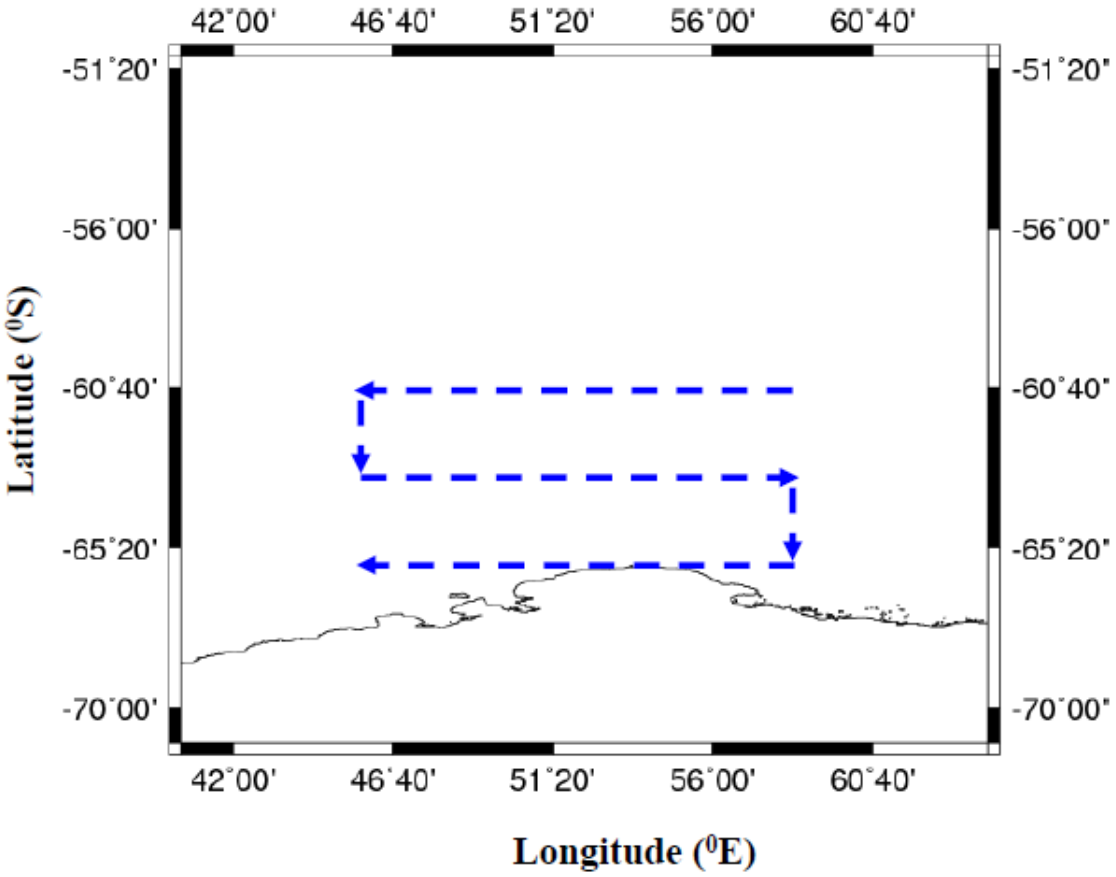

Figure 2: Tentative cruise track for intensive sampling in the Antarctic Zone.