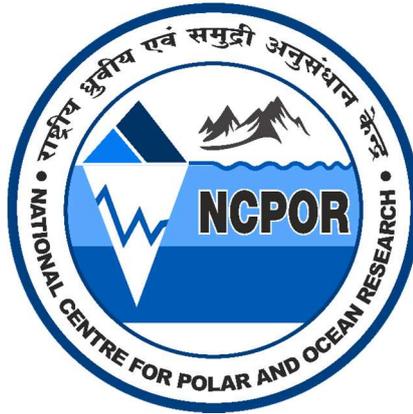


Cruise Plan

11th Southern Ocean Expedition (2019- 2020)



National Centre for Polar and Ocean Research (NCPOR)

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

Multi-institutional & Multidisciplinary investigations in the Indian sector of Southern Ocean

Background:

Southern Ocean (SO) is a unique region which tends to have a global scientific relevance in terms of its role in climate change, its distinct physical, chemical properties and the related biological processes. In the light of the biogeochemical perspective the SO in general and the Indian sector of the SO (ISSO) in particular, is still an understudied region. With the existing knowledge of SO it is quite impractical to derive any conclusion that can be useful for scientific understanding or societal benefits. Hence, a long term continuous study needs to be planned and executed on all interdisciplinary areas so as to obtain comprehensive understanding of the ISSO as well as its influence on Tropical Indian Ocean (TIO) and climate. As seen from available literature the studies that have been carried out in the ISSO are sparse; whereas most of the studies in the ISSO are confined to the Australian and African sectors. Long term monitoring in the ISSO would facilitate better understanding of the interactions between polar, subtropics, and tropics regions which would help us explaining the role of various processes occurring in the ISSO ecosystem in global climate change.

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 implications. Therefore sustained and multi-disciplinary observations are required to detect, interpret and respond to the changes in the Southern Ocean. Large amount of mass and heat transport is being occurred between Tropics, Subtropics and Polar regions due to the ocean and atmospheric circulations. The eastward flowing Antarctic Circumpolar Current (ACC) is the primary mode one by which water, heat and other properties are exchanged between the ocean basins through diapycnal mixing. Considering ACC as the boundary between tropics and polar oceans, measurements on the meridional heat transport between SO and tropical ocean is needed to assess its impact on tropical climate. The SO absorbs huge amount of carbon dioxide and transports it to the deep ocean. Thus plays a major role in the global carbon sequestration and cycling, strongly influences global climate patterns. The SO is a significant sink for anthropogenic atmospheric carbon dioxide (CO₂) and makes the SO a potential site for enhanced carbon sequestration. These processes may result in strong feedback on the nitrogen and oxygen cycling which are closely coupled with carbon cycle. The increase in uptake of CO₂ may also affect the ecosystem functioning by gradually reducing the pH, affecting the calcareous organisms and the overall biota of the oceanic system. Likewise the Particulate Organic Matter [POM] biogeochemistry and remineralisation influence the elemental cycles and the biological pump. The diverse spatio-temporal biogeochemical characteristics of the

various fronts in SO are need to be addressed time to time for understanding the role of SO in global ocean biogeochemistry. The changes in the oceanic hydrography and biogeochemical properties are consistently associated with long term global climatic changes.

In order to understand the processes those 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 Indian SO research program was initiated in 2004. This program was initiated by the Ministry of Earth Sciences (MoES) to pursue multi-disciplinary, multi-institutional research activities addressing various key scientific components including air-sea interactions, lower atmospheric processes, hydrodynamics, biogeochemistry, biodiversity (bacteria, plankton and higher marine organisms) etc. Since its inception in 2004, National Centre for Polar and Ocean Research (NCPOR) as the national nodal agency for planning, coordinating and executing all facets of SO research program, has carried out 10 expeditions addressing some of the above mentioned research components. The results obtained from these expeditions are quite encouraging as they provided some significant baseline data/information on various physical, biological and biogeochemical processes occurring across the various fronts in the SO. However, the information's gathered from these expeditions are not sufficient to establish the influence of SO on global climate and also at what extent the SO processes respond to or drive climate variability. This underscores the need for sustained observations from the SO to understand the physical and biogeochemical processes responsible for climate variability.

The dearth in the state of knowledge particularly from ISSO on the ecosystem responses to changes in carbonate chemistry, as well as POM biogeochemistry and remineralisation suggest the utmost need for a long term monitoring of the ISSO. Therefore, detailed investigations in the ISSO as well as TIO are significant to understand the tele-connection between high and low latitude biogeochemistry and climate changes.

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 (2004-2018) have attempted to understand the spatial and temporal variability of different fronts as well as the coastal processes in the ISSO based on the hydrographic data collected along various transects between 40°E and 80°E. Last five year’s SOEs (2011-12, 2012-13, 2014-15, 2016-17 & 2017-18) were mainly focused on the Subtropical Front (STF) to Polar Front (PF) and in the Prydz Bay (PB) region. Detailed studies on air-sea interaction, hydrodynamics, food web dynamics and biogeochemistry were carried out in the above regions of the ISSO 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 & 2018, detailed observations were made in the PB region during austral summer, however in the SO expedition 2019-20 it is planned to deploy an under-ice mooring for a period of one year, which could not be succeeded in the previous expedition. 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 it’s impact on this ecosystem. Further it is planned to implement continuous observations through the deployment of gliders between the subtropical and polar waters. Based on the in-situ, time series and glider deployment detailed observations are planned to be carried out to in the study region 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 alcove in the ISSO also will be studied to understand the complexities of the food web dynamics within this region. This needs to be addressed further to understand the role of SO in global climate change.

Towards achieving these goals, consequently, the 11th SOE to the Indian Ocean sector of the SO will be launched in December 2019/early January 2020 to have a comprehensive study in the region southwards of 40°S upto the coastal waters of Antarctica with the implementation of under ice mooring and glider deployment. The samplings during this expedition will be made for physical chemical, biological and geological studies with the scientific themes like Atmospheric sciences, Water column dynamics, Biogeochemistry, Foodweb dynamics and- 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 and the influence of melt-water/fresh water on it, water masses characteristics - bottom water, Heat budget variability, Current variability and influence of physical processes on biological production*

Further the studies 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 pursuit, in the eleventh 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.

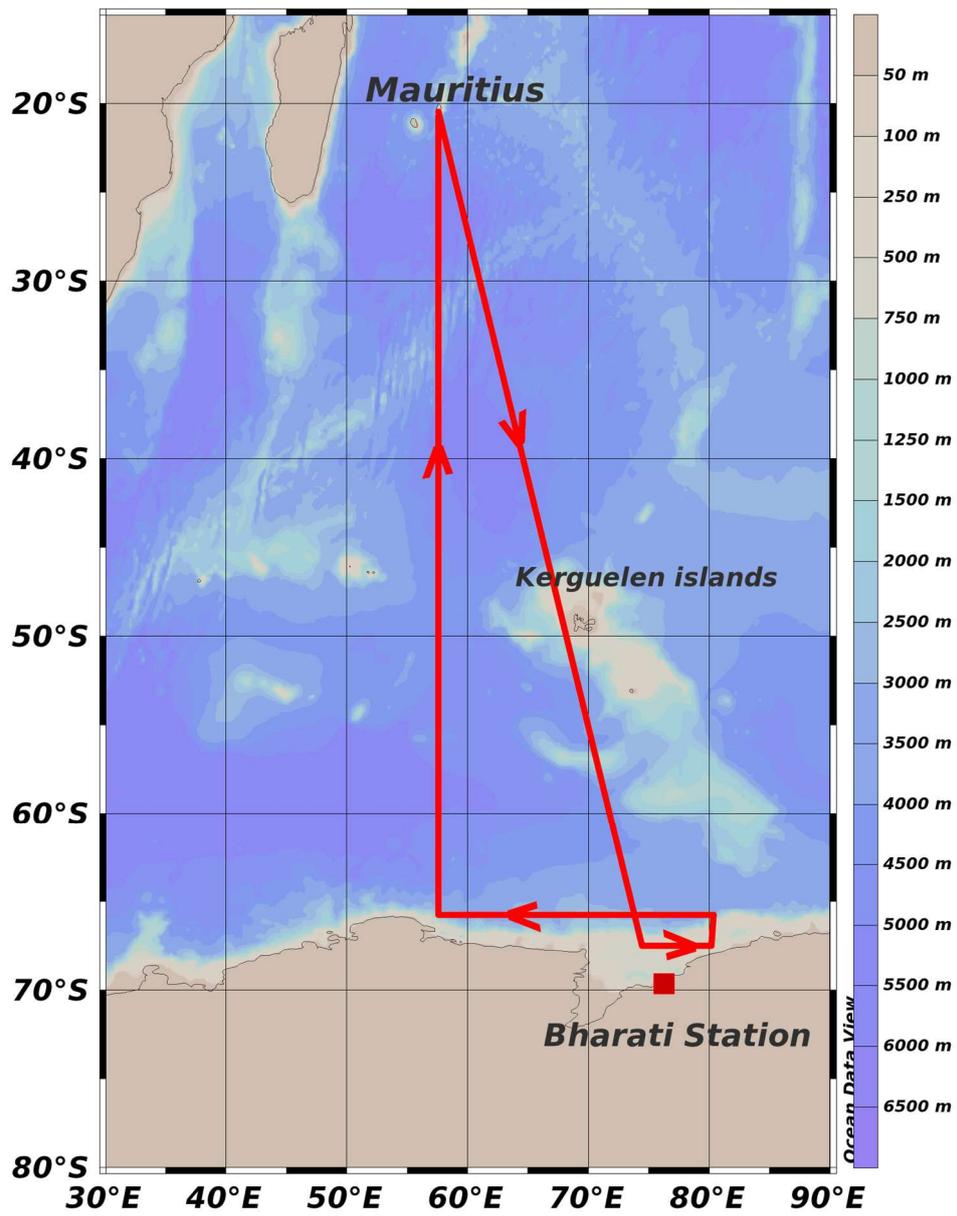
Research proposals relevant to the above focal themes are invited from research organizations, universities and other institutions engaged in R&D activities. The cruise track for the expedition is attached. The PIs, while proposing their research plan, may make sure to indicate the type of samples required, 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 **1st July, 2019** to,

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With a copy to,

The Director,
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(*Ministry of Earth Sciences*)
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The proposals will be reviewed by an expert committee constituted by Director, NCPOR 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 2019-20, may submit a proposal as a continuation of the studies carried out by them in the earlier SO expedition.



Tentative cruise track for SOE 2019-20