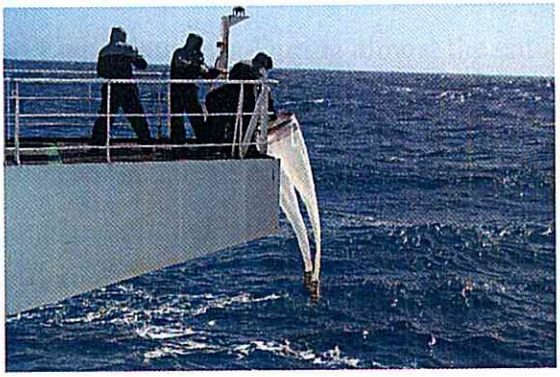
Cruise report



Bongo Net

Micro-profiler

Multiple Plankton Net

Coulometer

SN71 Southern Ocean Expedition 2013

11th January to 27th February 2013

PREFACE

As part of the ongoing efforts by NCAOR to broaden our understanding on the Indian Ocean sector of Southern Ocean, the 7th Indian Scientific Expedition to the Southern Ocean was launched on 11th January, 2013. The team consisting of 20 scientists from 8 National Institutes and Universities embarked on the expedition from Chennai onboard ORV *Sagar Nidhi*. The expedition was completed on 27th February, 2013 and the team disembarked at Port Luis, Mauritius. During almost the entire expedition the weather was very rough and sea state was high with big swells.

The major scientific operations carried out during the expedition are (number of operations/stations are given in brackets), Profiling of water column using CTD castings up to 1000 m depth (19); Water sample collection in the euphotic zone by messenger method upto 120 m depth (53); Firing of XCTDs to delineate the vertical structure of water column with high resolution (48); Microprofiler operations for turbulence studies (17); Deployment of Argo floats (4); Deployment of surface velocity drifters (8); Multiple plankton net sampling for zooplankton (17); Bongo net operation for collecting surface zooplankton (19); Primary productivity (^{14}C) estimation by deck incubation method (16); New production (^{15}N) estimation (12); Continuous current measurement of study region by the hull mounted ADCP; Continuous measurement of aerosols and black carbon; Mesocosom (micronutrient enrichment) experiment to investigate bacterial community and phytoplankton productivity (4); Continuous observations of atmospheric surface layer parameters using automatic weather station (AWS).

The data generated during this expedition will shed light into several interesting aspects, particularly hydrodynamics, biological productivity, organic carbon production and recycling etc. in the Southern Ocean system.

The salient features observed during the expedition are given below:

- At the centre of the eddy, chlorophyll concentration was nearly double compared with the non-eddy stations, indicating that the centre of the eddy contains sufficient nutrients to sustain the increased biomass.
- A prominent northward shift of Polar Front 2 (PF2) was observed. An intense temperature minimum layer was noticed in all the 6 stations along PF2.

- Strong temperature inversion was observed at around 50 m in the Subantractic front and the layer thickness was around 50 m.

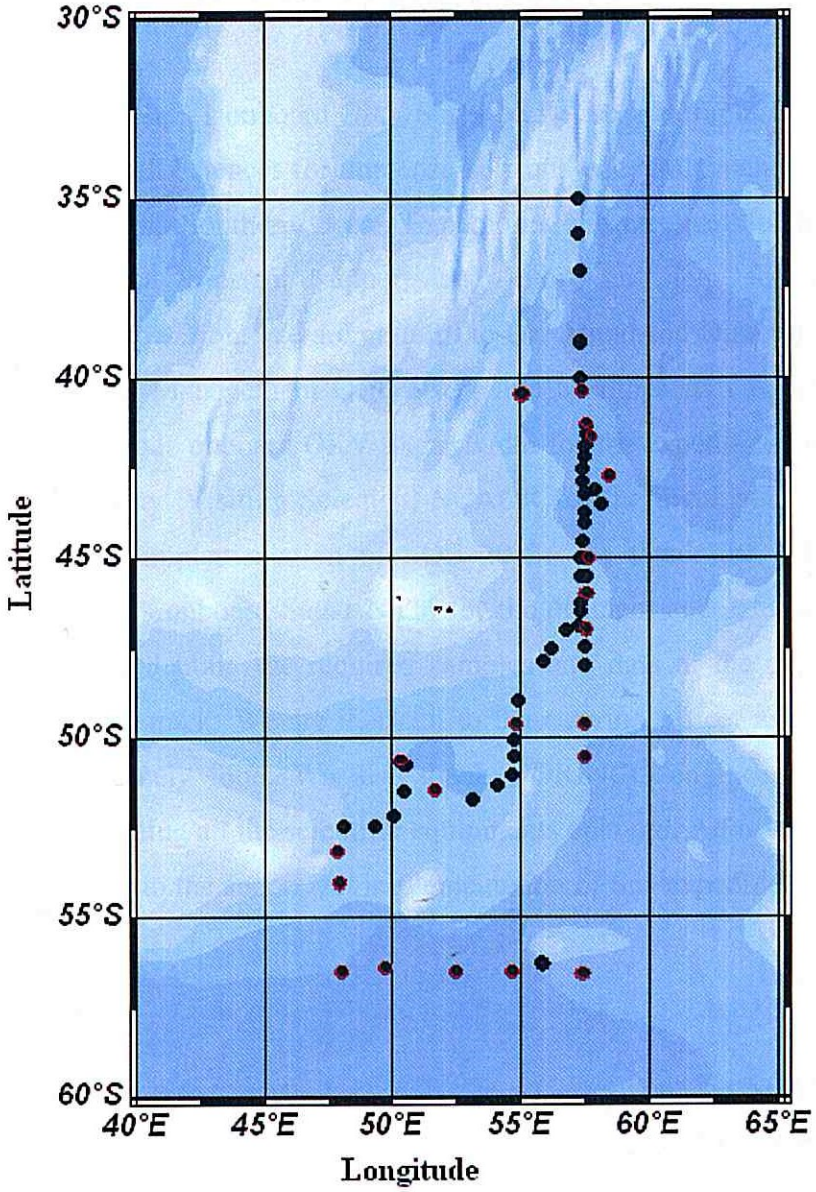
We encountered serious problems in operating the instruments and equipments for data and sample collection due to very bad weather and high sea state conditions almost throughout the expedition. As a result we lost one of our major equipments [CTD] due to the impact of a sudden freak swell at 56°30'S. Therefore we strongly recommend for scheduling the Southern Ocean expedition [SOE] during December-January months when fair weather conditions likely to prevail in this region. The time slot for SOE 2012-13 projected in the proposal submitted by NCAOR to the Joint Scientific and Technical advisory Committee (JSTAC) was from 5th December 2012 to 20th January, 2013.

We request the Member Secretary JSTAC to bring to the kind attention of JSTAC about the roughest weather and sea conditions faced by the SOE 2013 team and accordingly consider scheduling the SOE 2014 in such a way that the expedition commences from Mauritius around 10th December 2013.

Even in the bad weather/rough sea conditions tremendous efforts were made by the expedition members for data and sample collection, which would further enhance our knowledge and understanding of the Southern Ocean.

Sl. No	Instruments	No. of operations
1	CTD Carousel	19
2	Niskin Bottle Sampling (Messenger method in the euphotic zone upto 120 m)	53
3	XCTD	48
4	XBT	36
5	Micro profiler	17
6	Surface Velocity Profiler Drifters	08
7	Argo Floats	04
8	Multiple Plankton Net	17
9	Bongo Net	19

Table: operations carried out during SOE 2013



● Multidisciplinary stations with CTD;
● Multidisciplinary stations with meesenger & Niskin Sampler; ● - XCTD locations

Cruise track of the 7th Indian scientific expedition to Southern Ocean

ACKNOWLEDGEMENTS

We the scientific team of SN 71 onboard ORV Sagar Nidhi are grateful to Dr. Shailesh Naik, Secretary, Ministry of Earth Sciences for immense help and encouragements provided for the successful execution of this Southern Ocean Expedition. We are thankful to Dr. S. Rajan, Director,NCAOR for his constant support and enormous help for the successful implementation of this expedition. We are grateful to Dr. Atmanand Director, NIOT and Dr. Rajasekhar, Head, Vessel Management Cell, NIOT and all other staff in VMC for all the excellent arrangements made onboard ORV Sagar Nidhi for the expedition. We are thankful to Dr. C. T. Achuthankutty, Visiting Scientist, NCAOR for the invaluable suggestions and advice provided for the implementation of SOE 2013. We thank the Captain, all ABS Officers and crewmembers onboard Sagar Nidhi for the efficient and safe navigation of the vessel and for help in collecting the required samples and data at the preplanned station locations along the cruise track. We are thankful to the catering officer and all his staff for serving us tasty and homely food. We also thank NORINCO engineers for the service rendered by them in operating all the scientific equipments onboard. All scientists and staff of NCAOR who contributed to the successful implementation of this expedition are respectfully acknowledged.

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CHIEF SCIENTST

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1. Introduction

Polar regions have been identified as the areas where signatures of global changes are more pronounced. Improved understanding of the links between the Southern Ocean processes, global climate, biogeochemical cycles and marine productivity will be critical for the society to respond effectively to the challenges in climate change, sea level rise, ocean acidification and the sustainable use of marine resources. Research in the Southern Ocean realm underlines the sensitivity of this region to climatic variations and its importance in understanding the global climate at large. India already has a strong presence in Antarctica for the past 30 years. But, as compared to the scientific and logistics expertise gained by the country in Antarctica over the years, a wide gap exists in our knowledge of the Southern Ocean.

As part of the ongoing efforts to broaden our understanding of the Indian Ocean sector of Southern Ocean [SO], the seventh Indian Scientific Expedition to the SO was launched in January, 2013. The scientific team comprising 20 scientists representing various national institutes and universities across the country set sail from Chennai onboard ORV *Sagar Nidhi* on 11th January, 2013.

The major operations carried out during the expedition were (i) Profiling of upper 1000 m water column using CTD and collection of water samples with attached rosette system (ii) Micro-profiler operations for turbulence studies (iii) Multiple plankton net sampling for zooplankton (iv) Bongo net haul for collecting surface zooplankton (v) Firing of XCTDs to delineate the vertical structure of water column with high resolution (vi) Continuous observations of atmospheric surface layer parameters using automatic weather station (AWS). (vii) Continuous current measurements by hull mounted ADCP. Time series observations of physical, chemical and biological parameters were also carried out at certain locations in the Polar Front. The data generated during this expedition may throw more light on several intriguing aspects of the SO system.

2. Objectives

The main goal envisaged for the expedition is:

- "Role and response of the Southern Ocean to the regional and global climate variability"

Towards achieving this goal, the following scientific studies have been identified:

- Study of the inter relationship between physical, chemical and biological elements occurring across the Antarctic Circumpolar Current (ACC) and their role in carbon sequestration and biogeochemistry.

- Investigations on the air-sea-ice interaction and to understand the role of anthropogenic aerosols over the Southern Ocean.

- Implications of thermohaline variations in the Southern Ocean and the repercussion of heat and mass exchange between tropics and polar regions on biogeochemistry.

- Reconstruction of the paleo-environmental conditions for selected time slices during the last glacial-interglacial cycles to provide perspectives on future climate change.

- To generate relevant/critical sea truth and atmospheric data for contributing to global climate data sets for prediction of climate models to mitigate/regulate climate change.

3. Results from previous expeditions

Some interesting results obtained from the earlier expeditions and which are new for the study region are highlighted below:

- The Eddy Kinetic Energy [EKE] shows decadal increasing trend and meridional component of geostrophic velocity shows a trend towards negative implying an increase in southward transport. Southward transport of Subtropical Surface Watermass [STSW] and Subtropical Mode Watermass [STMW], which are subtropical in origin, warmer and more saline leads to its cooling and subsequent sinking, perhaps influencing the meridional overturning circulation.

- The causes for high productivity at Southern Subtropical Front [SSTF] above the southwest Indian ridge could be due to the intrusion of Antarctic Bottom Water, intensive mixing and shallow bottom. The influence of Agulhas Return Current from Agulhas retroflection and the water advected from Crozet Island could also be the causative factors for high productivity at SSTF above the Southwest Indian Ridge.

- Wind shift associated with Southern Annular Mode [SAM] is found to be the major reason for the anomalous bloom observed between 58°S and 62°S and 36°E and 47°E.