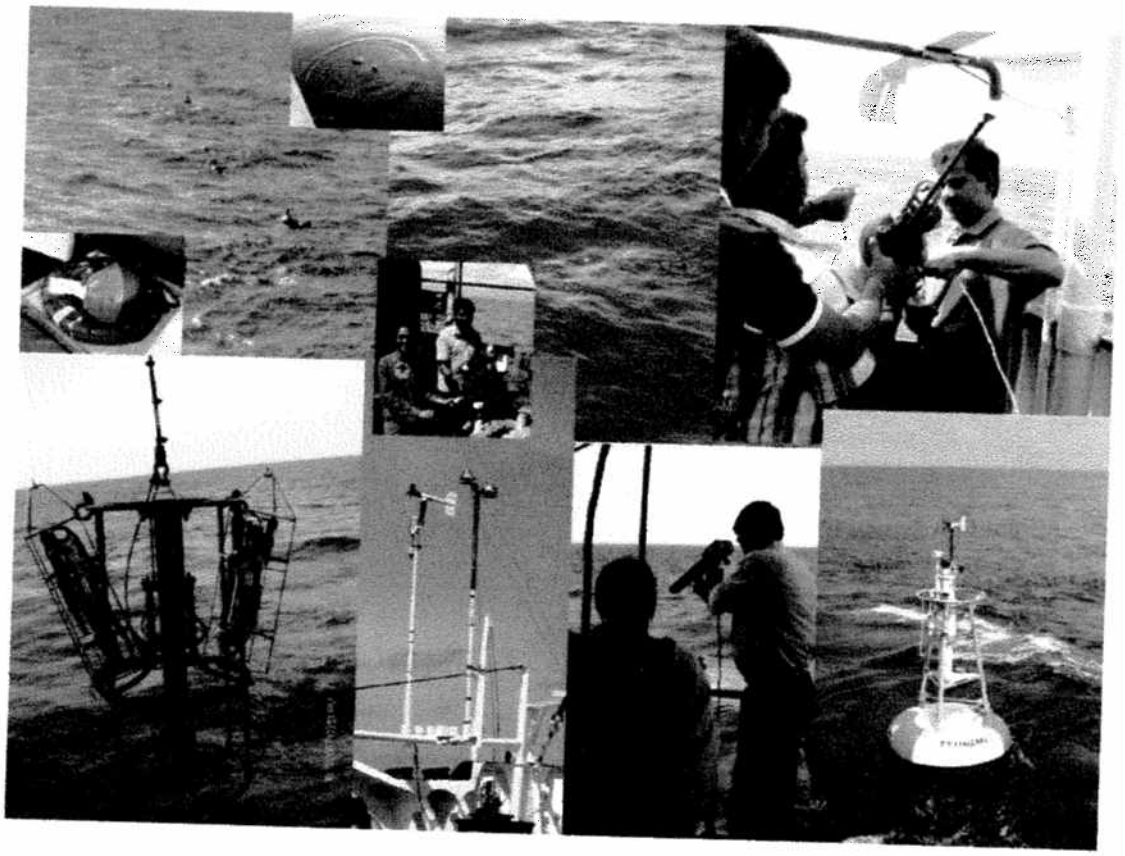
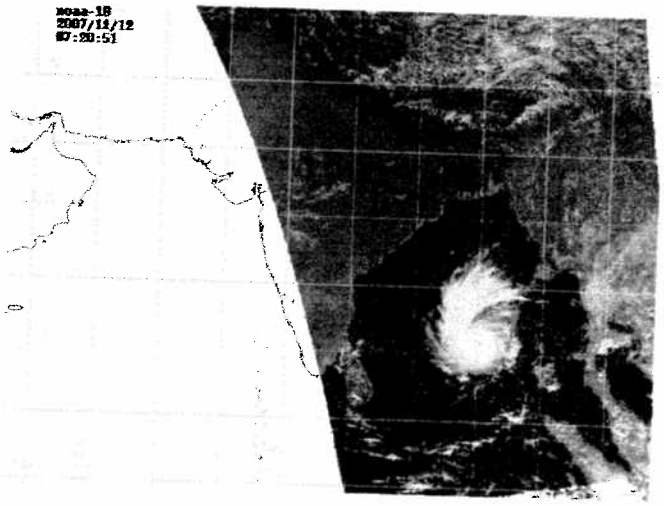
Recd from Dr. Ravichandran
Ch/Sc 8x 242A
14/12/07

Cruise Report – ORV Sagarkanya 242 A

Departure : Chennai, 10 Nov 2007
Arrival: Paradip, 23 Nov 2007
Region: Bay of Bengal

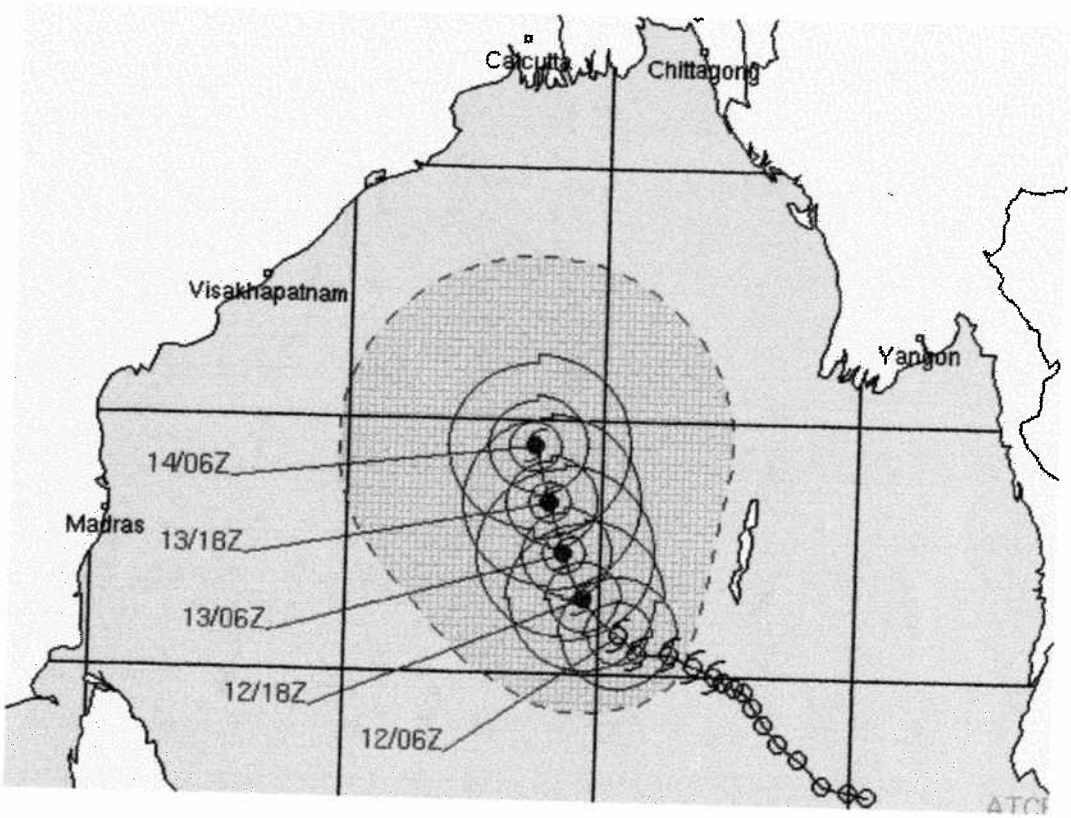




Contents

1. List of Participants
2. Itinerary
3. Introduction about the cruise
4. Objectives of cruise
5. Task accomplished
6. Performance of the equipment used
7. Performance of the ship
8. Conclusions
9. Recommendations / Suggestions

Acknowledgements



Cyclone Sidr location on 12 Nov 2007 at 0600 GMT, and its track forecast from JTWC, US

1. List of Participants

1. Dr. M. Ravichandran, INCOIS, Chief Scientist
2. Prof. D. Sengupta, IISc, Dy. Chief Scientist
3. Mr. A. Almeida, NIO
4. Miss. P. J. Vidya, NIO
5. Miss. Anuradha Modi, NIO
6. Dr. Aneesh A. Lotlikar, INCOIS
7. Mr. Adari Nagaraju, INCOIS
8. Bharathraj N. GOddalehundi, IISc
9. Dr. Arvind Sahay
10. Miss. Nivedita Sanwlani, SAC
11. Mr. Steven Paul Kunze, PMEL/NOAA, USA
12. Mr. Michael Ray Craig, PMEL/NOAA, USA
13. Mr. Mukund Chavan, NCAOR
14. Mr. Anil Patel, NCAOR
15. Mr. Sandip Chavan, NCAOR
16. Mr. Dipesh Tandel, NCAOR
17. Mr. R. Sivakumar, Seaman
18. Mr. P. Murugan, Seaman
19. Mr. Biju V. Nair, NORINCO
21. Mr. H. Raheman, NORINCO
22. Mr. A. C. Luis, NORINCO
23. MR. P. M. Mebish, NORINCO
24. Mr. R. Ravikumar, NORINCO

2. 0 Itinerary

Departure: Chennai, 10 Nov 2007
Arrival: Paradip, 23 Nov 2007

3.0 Introduction

The Bay of Bengal is considered to be an important observational platform for many investigations on air-sea interaction, monsoons, large scale circulation, remotely forced coastal circulation, tropical cyclones, climate variability and biogeochemistry of the region. During the last 4 decades, three major Monsoon Experiments were conducted during the southwest monsoon – the Monsoon Experiment (MONEX) in 1979, Marine Trough Boundary Layer Experiment (MONTBLEX) in 1990 [Narasimha et al., 1997] and Bay of Bengal Monsoon Experiment (BOBMEX) in 1999 [Sanjeeva Rao]. These Monsoon Experiments were conducted in the northern Bay of Bengal. The upper ocean temperature and salinity measurements were carried out at several stationary locations. Expect during MONEX in 1979, there were no time series measurements of currents in the northern Bay of Bengal. Several hydrographic surveys were also conducted to understand the upper ocean variability in the thermal and salinity and the associated circulation variability on seasonal scales [Murty et al., 1992 and Shetye et al., 1993]. Bay of Bengal Processes Studies (BOBPS) was the recent major field program to generate the multi-disciplinary data to under the biogeochemistry of the Bay [Prasanna Kumar et al., 2004, 2007]. Based on the comprehensive hydrographic data (Bay climatological data, cruises data and Argo data), Pankajskhan et al., (2007) documented the seasonal

variability of the barrier layer in the Bay of Bengal. While a basic understanding of the seasonal variability in the upper ocean hydrography and circulation in the Bay of Bengal is known either through observations and remote sensing and numerical modeling studies, still the temporal evolution of the near-surface temperature, salinity, mixed layer depth, barrier layer depth and currents in the upper 100 m in the northern Bay of Bengal is not known.

From the MONTBLEX data, Murty et al. (1996) documented the presence of shallow mixed layer within the large isothermal layer during the monsoon season of 1990 and the shallow mixed layer was attributed to the presence of low salinity waters. The subsequent BOBMEX data revealed the advection of a freshwater plume from the nearby coastal area into the offshore and helped documentation of the evolution of near-surface temperature and salinity, mixed layer depth and barrier layer during southwest monsoon of 1999 in the northern Bay of Bengal [Vinayachandran et al., 2002]. These experiments and other surveys showed the occurrence of large vertical and horizontal salinity gradients in the Bay of Bengal during the southwest monsoon. The BOBMEX results showed a spectacular event of arrival of freshwater plume at the time-series location (18°N, 89°E) in the northern Bay of Bengal. This made the Sea Surface Salinity (SSS) to fall by about 4 psu and the thickness of mixed layer to become thinner from 30 m to 10 m and thus resulted in the formation of barrier layer restricting the penetration of mixing processes to deeper depths. The offshore advection of fresh water plume was attributed to the Ekman flow in the upper 15 m [Bhat et al., 2001]. The intra-seasonal evolution of upper oceanic thermo-haline structure during BOBMEX period (July-August 1999) in the northern Bay of Bengal was found different from that in the central Bay. Though sea surface temperature (SST) responded to the spells of atmospheric convection (cloudiness) in both the regions, the SSS over the season as a whole increased (decreased) in the northern (southern) Bay of Bengal. The presence of barrier layer would lead to strong vertical and horizontal salinity and hence density gradients and suggests a strong current shear in the near-surface layer. However, there were no current measurements to document the vertical current shear in the near-surface layer wherein the freshwater plume is embedded.

Subsequent to the BOBMEX, the Arabian Sea Monsoon Experiment (ARMEX) was conducted during 2002-03 with measurements in the Southeastern Arabian Sea during June – August 2002 (in Phase I) and during March – June 2003 (Phase II) [Shenoi et al., 2004 and Sanjeeva Rao, 2005]. This observational program resumed in April – May 2005 (Phase IIA) to study the physics of the warm pool in the SEAS. In this program, a current meter mooring was deployed with four recording current meters (RCM) at 2 m, 7 m, 15 m and 25 m for about 14 days (20 April – 4 May, 2005) and time series of upper ocean temperature and salinity profiles were obtained at 4 stations around the mooring location in the Southeastern Arabian Sea (SEAS). The time-series near-surface currents data in the SEAS were found to be swift even under light wind conditions (near-surface slippery layer), and quite distinct from those at 15 m and 25 m. A strong current shear was revealed in the depth range of 2 m to 7 m and from 7 m to 15 m. However, the currents measured at 15 m and 25 m depth showed coherence. The near-surface 'slippery layer' and penetration of solar radiation beneath this layer, lateral advection and net heat flux at the sea surface appeared to be the controlling factors for the pre-monsoon warm pool SST in the SEAS [Sengupta et al., 2007]. The 'slippery layer' under the light wind conditions was noticed within the top low salinity layer, which is of Bay of Bengal origin and got advected into the SEAS through the East India Coastal Current (EICC) during October – December and Winter Monsoon Current (WMC).

Recently, Sengupta et al., [2006] reported the recent estimates of the annual total continental runoff into the Bay of Bengal as about 2950 km^3, which is more than half that into the entire tropical Indian Ocean (IO). These authors further reported that the thin layer of freshwater (may be of 5 m thick) from the Bay of Bengal moves out into the equatorial region and then into the South Equatorial Current (SEC), making its long way and effecting the salinity *en route* from the Bay of Bengal to the southern tropical Indian Ocean. However, there are no time series measurements of currents together with salinity and temperature in the near-surface layer (0-60 m) to understand the variability of currents to document the existence of a 'slipper layer' in the Bay of Bengal, the source region for the freshwater plumes. Murty et al. [2002 and 2004] proposed that plume of freshwater and atmospheric convection over the Bay of Bengal is closely related. Murty et al. [2000] also reported that about 55-60% of heat content relative to the depth of 26°C isotherm (D_{26}) is available within the thickness of the freshwater plume (low salinity layer).

The Bay of Bengal experiences a good number of weather disturbances (eg., monsoon depressions and tropical cyclones etc) in a year and the response of the northern Bay even to the intense disturbances appears to be weaker at the sea surface and strong at the depth. The weaker SST drop to the disturbance is attributed to the presence of strong salinity stratification [eg., Murty et al., 1996], though strong vertical temperature gradients are expected at depth below the salinity stratified layer. The proposed observational set up with high temporal and spatial resolution in the upper ocean parameters in the upper 100 m will help document the Bay's response to the cyclone and also to help validating the model (being developed at IISc).

Meso-scale eddies are known to exist in the Bay of Bengal (BoB) way back in 1957 [*Ramasastry and Balaramurty*] off Vishakhapatnam along the western boundary of the BOB during March-April and October-November. Subsequently, *Rao and Sastry* [1981] reported cyclonic and anti-cyclonic flows. Though the existence of eddies in the BOB has been documented by several authors [*Ramasastry and Balaramamurty*, 1957; *Rao and Sastry*, 1981; *Legeckis*, 1987; *Babu et al.*, 1991; *Murty et al.*, 1993; *Shetye et al.*, 1993; *Sanilkumar et al.*, 1997; *Babu et al.*, 2003; *Madhusoodhanan and James*, 2003] their role in the context of biological production and biogeochemical changes were not known. Based on 2001 summer monsoon data, *Prasanna Kumar et al.* [2004] identified cold core eddies in the Bay of Bengal and proposed eddy pumping as a possible mechanism of vertical transfer of nutrients across the halocline to the oligotrophic euphotic zone during summer monsoon, when the upper ocean is highly stratified. This cold-core eddy was found to enhance the biological productivity by more than double. The *in situ* measurements show that these eddies mostly confines with in the upper 500 m of the water-column and have horizontal dimension of 200 to 300 km. Recently concluded Bay of Bengal Process Studies (BOBPS) (2000-2006) clearly demonstrated that eddies are ubiquitous in the Bay of Bengal and they occur during all the seasons [*Prasanna Kumar et al.*, 2007]. They develop from the hydrodynamic instabilities and alter the physical and biochemical properties of the water column. ***Though the Bay of Bengal Processes Studies (BOBPS) Program brought into focus the importance of eddies in enhancing the biological productivity of the Bay of Bengal, the quantification of eddy-induced fluxes is yet to be done.***

In order to generate the high quality data with high resolution in the northern Bay of Bengal to investigate the evolution of mixed layer, current structure in the near-surface layer, and its heat and salt budgets during the period of intense inflow of run-off into the Bay and its subsequent spread into the interior Bay as freshwater plumes (or thin low salinity layers), an observational experiment is proposed. The experiment is proposed in the northern Bay of Bengal with time series measurements at 18°N, 89°E. Multi-disciplinary measurements are also proposed along 18°N latitude and closer to the time series location to understand the eddy-induced biogeochemical fluxes. It is also proposed to initiate the sediment trap measurements at the Bay Climate Observatory Location (18°N, 89°E) in the northern Bay to understand the dynamical/passive linkages between the upper ocean processes and deeper ocean.

Further, in order to quantify the eddy-induced fluxes in the northern Bay of Bengal, it is also proposed to undertake *in situ* water column measurements within and outside eddy region for flux quantification. The measurements will include all physical, chemical and biological parameters in accordance with the protocol of JGOFS (Joint Global Ocean Flux Study).

4.0 Objectives

- To generate a high quality data on temperature, salinity, oxygen and chlorophyll by deploying CTD at different location to study coastal and northen Bay hydrology.
- To generate quality data on surface meteorological parameters in the Bay of Bengal.
- To describe the sub-intraseasonal variability in the near-surface fields of temperature, salinity, oxygen and chlorophyll in the northern Bay of Bengal.
- To investigate the evolution of mixed layer and the mixed layer heat and salt budgets in the northern Bay of Bengal during the observational period.
- To investigate the upper ocean response to a tropical cyclone.
- To deploy two PMEL/NOAA ATLAS mooring one at 12N/90E and other at 15N/90E as part of IndOOS observational program of CLIVAR/IOGOOS.
- To deploy 10 Argo floats with 5 day sampling to measure temperature, salinity and oxygen upto 500 m depth.
- To deploy 10 Drifters as a part of WMO-IOC Pilot Iridium project of Data Buoy Cooperation Panel (DBCP)
- To measure sub-surface radiation using Hyperspectral radiometer.

5.0 Task accomplished (summary of day to day activities)

10-11-2007

In order to calibrate different CTDs (Idronaut, NIO-SBE, NCAOR-SBE), all three CTDs were attached to main frame and acquired data from all.

16.20 hrs : CTD operation upto 75 m depth at 13d 03 mN/80d 29m E (stn1)
18.25 hrs: CTD operation upto 201 m depth at 13d 05m N/80d 36m E (stn 2)
20.35 hrs: CTD operation upto 325 m depth at 13d 04m N/80d 41m E (stn 3)
23.13 hrs: CTD operation upto 540 m depth at 13d 03m N/80d 54m E (stn 4)

Surface salinity was increasing as we go away from the coast. Thermal inversions were observed at some locations. All the CTDs are observed to be working fine, but Idronaut CTD has some pressure offset.

11-11-2007

01.50 hrs: CTD operation upto 535 m depth at 13d 01m N/81d 04m E (stn5)
05.33 hrs: CTD operation upto 530 m depth at 12d 59m N/82d 11m E (stn 6)
11.00 hrs: Radiometer observations at 12deg51min N / 82deg 11.5 m
14.00 hrs: Radiometer observations at 12 deg47.35min N /82deg 31.58min
14.40 hrs: XBT deployment at 12d46m N/ 82d31m E (XBT1)
18.30 hrs: CTD operation upto 1040 m depth at 12d 42m N/83d 00m E (stn 7).
21.00 hrs: Argo float testing

12-11-2007

09.30 hrs: CTD operation upto 1000 m depth at 12d 24m / 85 E + Water sampling for 8 depths from 200m to 1000m. One bottle could not fired properly (stn 8)
10.30 hrs: Radiometer observations at 12deg24min N / 85deg11min
11.00 hrs: CTD cable was tested with dummy weight of 250 kg upto 2600 m depth and found there was no problem in the cable. Hence, decided to use upto 2000 m CTD operation henceforth.
13.40 hrs: XBT deployed at 12deg35 min N/ 83deg59min (XBT2)
14.00 hrs: Radiometer observations at 12deg19min N/85deg19min

Message received from INCOS/IISc/NCAOR regarding a deep depression formed over 10.5 N/ 92 E, and soon developed into a cyclone at 12 N / 90E, where the PMEL/NOAA proposed buoy location. Hence, the vessel was diverted to south (towards 10deg N) after careful analyzing the different satellites pictures.

13-11-2007

17.30 hrs: Two drifters were deployed at 9deg41N and 86deg48E (NIO)
No other scientific operation today

14-11-2007

After receiving Cyclone update and forecasts from INCOIS/IISc/NCAOR, the vessel was heading towards 12 N / 90 E, the buoy deployment location.
10.10 hrs: Argo deployed at 88deg29min /90deg36min E (argo2)
10.26 hrs: XBT launch at 9d 33m N /88d26m E (XBT3)

15-11-2007

10.00 hrs Bathymetry survey was carried out for 5 sq. miles using Multibeam echosounder. Data acquisition is fine but problem in visualization.
12.00 hrs PMEL/NOAA buoy deployed
15.00 hrs Anchor dropped at 11 d 55m N / 89d 56m E
16.00 hrs Radiometer operation at 11deg 57min /89d 58 E
19.00 hrs: CTD operation upto 2500 m with water sampling at 8 different depths. But Irdonaut CTD failed after 750 m depth. It was found that there was no electrical

communication from Idronaut CTD. After inspecting, it was found that the drum and shaft were not rotating in a synchronous manner.
19.30 hrs: CTD operation at 12deg01min N/89deg45min E with portable SBT-CTD attached with weight to Deep sea winch. Operated upto 2500 m depth (stn 9)
2330 hrs: Argo float deployed at 12deg 01min N/ 89deg 46min (argo2)

16-11-2007

06.00 hrs: CTD operation upto 2200 m depth at 13d 00m N/90d 00m E (stn 10)
10.00 hrs: Radiometer operation at 13deg13min N / 90 E
10.45 hrs: XBT operation at 13d29m N / 90 E (XBT4)
14.00 hrs: Radiometer operation at 14deg/90E
14.40 hrs: CTD operation upto 2500 m depth at 14d 00m N/89d 59m E (stn 11)
16.25 hrs: two drifters were deployed (NIO) at 14deg02N / 90 E
16.50 hrs: Argo float deployed at 14deg N / 90 E (argo 3)
19.15 hrs: CTD operation upto 600 m depth at 14d 30m N/ 90 E (stn 12)
22.30 hrs: CTD operation upto 2400 m depth at 15N/90E (stn 13)

17-11-2007

0500 hrs: Survey about 3 sq.miles using Multibeam echosounder. Decided the location for dropping anchor.
09.20 hrs: PMEL/NOAA buoy deployed in water at 14deg54min N/ 89deg58minE
09.30-12.00 hrs: Rope paying out is in progress
12.15 hrs: Anchor dropped at 14d 58min N / 89deg 59min E
Vessel moving away from buoy for CTD operation
14.00 Radiometer operation at 14deg59min / 90deg 3min E
14.15 hrs: CTD operation upto 2500 m 14de 58min N / 90deg 03 min E (stn 14)
16.35 hrs: Argo floats deployed at 90E/15N + two drifters were deployed (argo 4)-INCOIS
21.15 hrs: XBT deployed at 15deg13min N/89deg38min (XBT 5)
2315 hrs: CTD operation upto 2200 at 16deg N / 89 deg E (stn 15)

18-11-2007

0115 hrs: Argo floats deployed at 89deg 13 E/16 N(argo 5)
02.25 hrs: XBT deployed at 16deg13 min/ 89deg10min (XBT 6)
0440 hrs: CTD operation upto 2200 at 16 deg 29min N / 89 E (stn 16)
07.25 hrs: XBT deployed at 16deg30min N/89deg 10min E (XBT 7)
0910 hrs: CTD operation upto 2300 m at 16 deg 30 min N / 89 E 17 min (stn 17)
10.50 hrs: Radiometer operation at 16deg31min N / 89deg 15min
11.15 hrs: Aft CTD winch performance testing with 75 kg dummy weight. Due to break problem, could not test further
1140 hrs: Argo float deployed at 89deg17min E/16deg30min N (argo 6)
1320 hrs: XBT deployed at 16deg30min N/89deg30min E (XBT8)
1440 hrs: Radiometer operation at 16deg30min N / 89deg 35min E
1530 hrs: CTD operation at upto 2200 at 16deg29 N/89deg 35min (stn 18)
1820 hrs: XBT deployed at 16deg45min89deg27min (XBT 9)
2010 hrs: CTD operation upto 2200 at 17 N/89deg18E (stn 19)
2100hrs: Argo and a drifter were deployed at 89deg18min/17 N (Argo 7)

19-11-2007

0045 hrs: XBT deployed at 17deg29min N/89deg18min E (XBT 10)
0425 hrs: CTD operation upto 2000 m at 17deg59min/89deg17min (stn20)
0600 hrs: Argo deployment at 89deg16min/18 N (argo 8)
0920 hrs: XBT deployed at 18deg 30min N/89deg 18min E (XBT11)
0945 hrs: Four Drifter buoy deployed at 18deg33min N/89deg18min E (2 INCOIS + 2 NIO) two 5m trough and two 15 m trough (clearwater and metocean), wind and without wind.
10.45 hrs: Radiometer operation at 18deg 41min N / 89deg17min E
1330 hrs: CTD operation upto 1600 m at 19deg N/89deg17min E (stn 21)
1430 hrs: Argo float and a drifter (INCOIS-15m) deployed at 19deg N/89deg16min E (argo 9)
17.32 hrs: XBT deployed at 19deg 31min N/89deg 18min E (XBT12)
2055 hrs: CTD operation upto 1100 at 20 N/89deg17min (stn 22)

20-11-2007

01.10 hrs: XBT deployed at 20deg N/88deg 30min E (XBT13)
0400 hrs: CTD operation at 20N/88E upto 900 m (stn 23)
06.56 hrs: XBT deployed at 19deg 39min N/87deg 59min E (XBT14)
1040 hrs: CTD operation at 19N/88E upto 2000 m (stn 24)
15.00 hrs: XBT deployed at 18deg 30min N/87deg 59min E (XBT15)
1745 hrs: CTD operation at 18 N/88 E upto 2000 m (stn 25)
2140 hrs: Argo float deployed at 18deg16min/87deg39min (argo10)
2300 hrs: CTD operation at 18deg 22min/87deg34min upto 500 m (stn 26)

Time series observation at DS4 location started

21-11-2007

0130 hrs: CTD operation upto 500 m at 18deg 22min / 87deg31min (stn 27)
0430 hrs: CTD operation upto 500 m at 18deg 21min / 87deg32min (stn 28)
0730 hrs: CTD operation upto 500 m at 18deg 19min / 87deg30min (stn 29)
1030 hrs: CTD operation upto 500 m at 18deg 22min / 87deg33min (stn 30)
1330 hrs: CTD operation upto 500 m at 18deg 20min / 87deg32min (stn 31)
1630 hrs: CTD operation upto 500 m at 18deg 18min / 87deg30min (stn 32)
1930 hrs: CTD operation upto 500 m at 18deg 21min / 87deg32min (stn 33)
2230 hrs: CTD operation upto 500 m at 18deg 19min / 87deg30min (stn 34)

22-11-2007

0130 hrs: CTD operation upto 2000 m at 18deg 16min / 87deg27min (stn 35)
0630 hrs: CTD operation upto 2000 m at 18deg 46min / 87deg20min (stn 36)
1000 hrs: CTD operation upto 1000 m at 19deg 07min / 87deg12min (stn 37)
12.33 hrs: CTD operation upto 1500 m at 19deg18 min / 87 deg 07 min (stn 38)
15.50 hrs: CTD operation upto 1200 m at 19deg32.42min / 87deg 00.05 (stn 39)
1700hrs: Aft CTD winch tested with 250 kg with 500 m and working satisfactorily.
20.00 hrs: CTD operation upto 500 m at 19deg 42min / 86deg57min (stn 40)
22.00 hrs: CTD operation upto 500 m at 19deg51min/ 86deg52min (stn41)

23-11-2007

0100 hrs: CTD operation upto 30 m at 20deg 00min / 86deg50min (stn 42)

Reached Anchor position at 01.00 hrs.

6. 0 Performance of the equipment used

The following equipment/instruments were used during the cruise. All of them worked satisfactorily

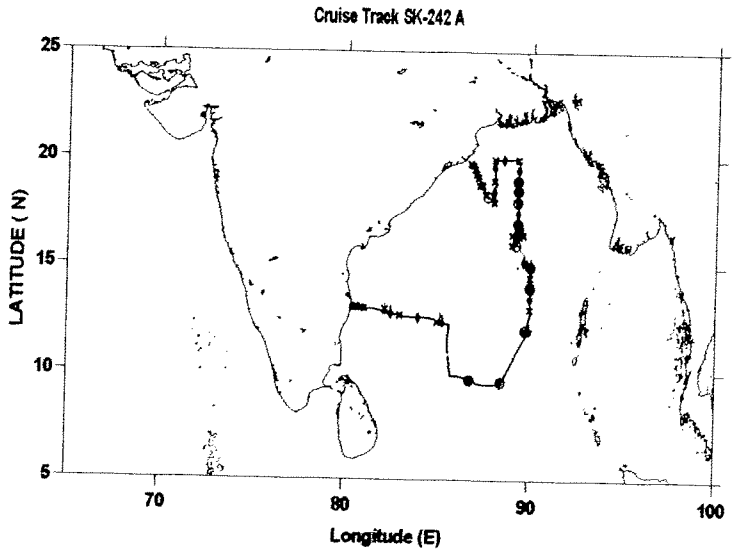
1. Deep sea winch
2. Crane (port side) and (starboard side)
3. Autosal analyzer
4. CTD
5. Multibeam echosounder (Visualization of 3d/2d map is required to customized)
6. Single beam deep sea echo sounder
7. Bucket thermometer
8. XBT launcher

8.0 Performance of the ship

Performance of the ship on the whole was satisfactory, specifically DP system, air conditioners in the accommodation and lab.

8.0 Conclusions

The Objective of the cruise was accomplished such as deployment of moored buoys, Argo floats, drifters, XBT, Radiometer and CTD operations. The cruise track and different operations performed during the cruise are shown in Fig. 1. Due to winch problem, we could not collect water samples. It was a fantastic opportunity to follow the cyclone path and conduct CTD and radiometer operations. There are about 35 CTD operations were conducted, 11 Radiometer operations, 10 argo floats deployed, 12 drifters deployed during this cruise. In general, the cruise was successful one and all the scientists onboard enjoyed in doing different operations.



9.0 Suggestions / Recommendations

1. AWS ingesting Ship's speed and heading (Gyro) is important to install onboard ORV Sagarkanya
2. PCs may be upgraded with virus protection
3. Internet facility onboard would improve some of the operational activities.
4. Thermosalinograph need to be installed.
5. Washing machine for Scientists/Engineers may be provided
6. Extra electrical power points may be provided at rooms and labs.

Acknowledgements

SK-242A team (Chief Scientist and Participants) place on record their deep sense of gratitude to Director, NCAOR for making available ORV Sagarkanya for this cruise. Dr. M. Sudhakar, Scientist G & Group Director, NCAOR and his team always helpful in different stages of the cruise and WE all sincerely thank them. Special thanks to Mr. M. subramaniam, NCAOR for different help rendered during the cruise.

Captain K. S. Pandian and his team were always helpful and very cooperative during the Cruise. We all appreciate manual ½ hour log entry of wind and other parameters from Bridge. Whenever we approach them, they understand the situation and help us accordingly. Special thanks to Chief Engineer, Chief Officer and Second Officer. Radio Officer was always with us during needy time, especially during cyclone days. We all enjoyed the food during the cruise and thanks to Catering officer and his team for the excellent food.

The Norinco engineers were always helpful with smile (day or night). They were helpful in all the activities such as CTD cast, deployment of floats and drifters, etc. We sincerely acknowledge them for their effort.

Mr. Devender, INCOIS, Prof. Bhat, Prof. Venugopal and Mr. Subramaniam, NCAOR were helpful in sending satellite images, track forecast and ship avoidance map during the cruise. Their help is gratefully acknowledged.