

ORV SAGAR KANYA

CRUISE REPORT

Cruise No. SK-277

Submitted to

National Centre for Antarctic and Ocean Research

Headland Sada, Vasco-da-Gama, Goa

Submitted by

Dr. Vimlesh Pant

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Indian National Centre for Ocean Information Services

Hyderabad – 500055

Objectives of the Cruise

The cruise (SK-277) was a multidisciplinary cruise organized from Chennai – Bay of Bengal – Chennai during October 22 – November 18, 2010 onboard research vessel ‘ORV Sagar Kanya’. Total 29 participants drawn from 7 scientific organizations, including 3 scientists from USA, participated for the oceanographic and atmospheric research work during the cruise.

Following are the planned scientific objectives of the cruise SK-277.

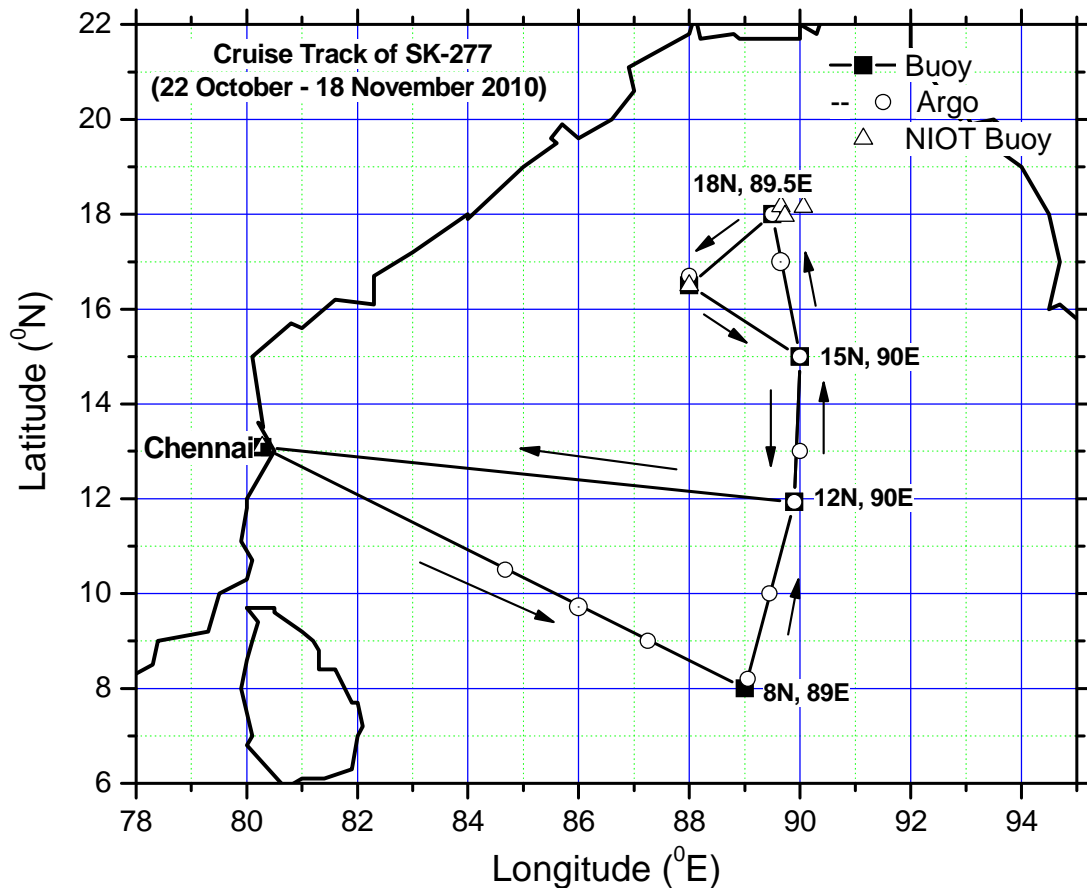
1. Recovery and redeployment of three RAMA moored Buoy (NOAA/PMEL) at 8.0 N, 89.0 E; 12.0 N, 90.0 E; and 15.0 N, 90.0 E locations.
2. Recovery of one cone-head mooring Buoy (INCOIS buoy) with subsurface sensors from 18.0 N, 89.5 E location.
3. Deployment of three Data-Buoy (NIOT buoy-BD01, BD02, and BD03) at 18.16 N, 89.66 E; 17.96 N, 89.73 E; and 16.5 N, 88.0 E.
4. Search and recovery of one data Buoy (MB12) at 18.15 N, 90.06 E.
5. Deployment of Argo floats (autonomous temperature and salinity profiling floats) along the cruise track at different locations. In total 12 Argo floats planned to deploy during the cruise.
6. Conductivity-Temperature-Depth (CTD) profiles up to 2000 m depth at every Buoy deployment/retrieval location and Argo float locations.
7. Launching of 4 Expendable Bathythermograph (XBT) probes simultaneously along with CTD at six locations.
8. Deployment of two drifter buoy during the cruise.
9. Measurements of concentration of atmospheric aerosols, black carbon, trace gases (including CO, Ozone, NO_x) along the cruise route throughout the cruise period.
10. Collection of water samples from 21 depths up to 2000 m using CTD sampling bottles at 5 locations in the Bay of Bengal.
11. Zooplankton and Phytoplankton sample collection from 200 m depth at five locations during the cruise.
12. Three hourly meteorological observations throughout the cruise period.
13. Radiosonde (RS/RW) balloon flights planned to be launched twice daily.

List of Participants:

Sl No.	Name	Designation	Organization
1	Dr. Vimlesh Pant	Chief Scientist	INCOIS, Hyderabad
2	Mr. David Keith Zimmerman	Dy. Ch./Sc.	NOAA,USA
3	Mr. Suresh Kumar N	Scientist	INCOIS, Hyderabad
4	Mr. William Lester Higley Jr.	Scientist	NOAA,USA
5	Mr. Stephen Allen Smith	Scientist	NOAA,USA
6	Mr. Mallik Chinmay	Scientist	PRL, Ahmedabad
7	Mr. Srivastava Rohit	Scientist	PRL, Ahmedabad
8	Mr. Gautam R. Choudhury	S.A.	IMD, Delhi
9	Mr. Brahum Paul	S.A.	IMD, Jammu
10	Mr. Ramesh Krishnamoorthy	Technical Assistant	NIOT, Chennai
11	Mr. Gnanadhas Thasian	Proj. Tech. Assistant	NIOT, Chennai
12	Mr. P. Ramesh	Proj. Skilled Asst.	NIOT, Chennai
13	Mr. Sivaraj Vasudevan	Technician	NIOT, Chennai
14	Mr. Elango Sivalingam	Engineer	NIOT, Chennai
15	Mr. Mithun Gawas	Research Fellow	NIO, Goa
16	Mr. Thorat Babasaheb Rajaram	T.O.	NIO, Goa
17	Ms. Soares Melena Augusta	P.A. II	NIO, Goa
18	Ms. Naik Shusma Chandrakant	P.A. II	NIO, Goa
19	Mr. P. Krishna Kanth	Lecturer	A.N. Univ., A.P.
20	Mr. Bibin Abraham	Shipboard Asst.	NCAOR, Goa
21	Mr. Manivannan Dayalan	Engineer	NORINCO (AMC)
22	Mr. Rajapandian Karthickraja	Engineer	NORINCO (AMC)
23	Mr. Yerramilli Krishna Chaitanya	Engineer	NORINCO (AMC)
24	Mr. Tachezhath Baiju	Engineer	NORINCO (AMC)
25	Mr. Kaliraj Vijayaraghavan	Engineer	NORINCO (AMC)
26	Mr. Selvaraj Emayavaramban	Seaman	INCOIS
27	Mr. Rajasegar Arumugam	Seaman	INCOIS
28	Mr. Yuvaraja Arumugam	Seaman	INCOIS
29	Mr. Venkatesan Selvaraj	Seaman	INCOIS

Note: Mr. P. Krishna Kanth was signed off on medical grounds. He was suffering from severe migraine and recommended for signoff by Medical Officer onboard. Finally he was signed off on 26 October 2010 after getting approval from Director, NCAOR.

Cruise Track:



Recovery and Redeployment of RAMA mooring Buoy:

The Research Moored Array for African Asian Australian Monsoon Analysis and Prediction (RAMA) moored buoy is an international program of 'Global Ocean Observation System' (GOOS). Three RAMA buoy were recovered and redeployed at locations 8N, 89E; 12N, 90E; and 15N, 90E in the Bay of Bengal by NOAA/PMEL scientists during this cruise.

The recovery operation start with citing the buoy on Radar and visually. The vessel then moved close (up to 100 m) to the buoy float. Buoy is then released from the anchor weight by sending acoustic pulses to the 'Acoustic Release'. After that a small zodiac boat, carrying scientists, lowered from the ship. This boat approached to the buoy and all meteorological sensors (wind speed and direction, solar radiation, humidity and air temperature) taken off from the buoy tower. The buoy is then hooked with a rope which is passed to the boat from ship. Finally the buoy was recovered on the main deck using A-frame and Deep-sea winch. After recovery of the buoy float, the cable was pulled by deep sea winch and all sub-surface sensors were taken off from the mooring cable. Similar procedure followed for recovery of all RAMA buoy during the cruise.

Deployment of RAMA buoy float was performed from the starboard side of the ship using a crane mounted outside of deep-sea winch control room. Before the deployment, the top tower, with all meteorological sensors clamped on it, was fixed on the float. Then a cable was connected to the bottom tower of float and subsurface sensors were clamped at defined depths on the mooring cable. The cable was laid along the starboard boundary of the ship towards the ship aft. The buoy was deployed using the crane on starboard side and cable passed from the aft using the Wintech winch of NOAA. After completing 600 m of nilspin cable payout, the nylon rope was connected to the buoy mooring line for remaining length up to sea-bed. At the end, acoustic release was connected to the line, followed by the heavy anchor weight. The anchor was dropped using deep-sea winch and A-frame from the ship aft. Similar procedure followed for all three RAMA buoy deployments.

Details of deployments of RAMA buoy are as below,

Sl. No.	Longitude	Latitude	Date	Time
1	89° 00.594'E	08° 01.466'N	01.11.2010	1900 IST
2	89° 54.380'E	11° 56.042'N	03.11.2010	1845 IST
3	89° 58.166'E	15° 00.700'N	05.11.2010	1830 IST

Note:

After successful deployments of RAMA buoy at three locations, at a later time during cruise (on 10 November at location 18.0N, 89.5E) information received from NOAA/PMEL, USA regarding failure of temperature sensor on RAMA buoy at 12N, 90E, and non-functioning of meteorological sensors at 15N, 90E. Mr. Zimmerman, scientist from NOAA, requested to visit these two buoy again to investigate the problem and repair/replace faulty sensors. As the deployments of RAMA buoy was one of the major objectives of the cruise, it was decided to change the track of cruise after NIOT third buoy (BD03 at 16.5N, 88.0E) deployment and fix the faulty sensors of RAMA buoy at 15N, 90E and 12N, 90E.

Upon visiting the 15N, 90E buoy, it was found that the temperature and humidity sensor shield was broken and absent. A new temperature and humidity sensor module was fixed on the buoy by NOAA/PMEL scientists using the zodiac boat on 12 November 2010 at 18:00 IST.

At the second faulty buoy location (12N, 90E), surprisingly it was found that the top tower of the buoy was broken and hanging underwater on a rope below the float. The reason for breaking of top tower suspected to be either a strong hit by passing ship, or damage caused by fishermen. The small boat was lowered and the rope holding the hanging tower was cut to release it. The float (without a top tower and sensors) was then recovered on the main deck and a new tower with all new meteorological sensors was fixed on the float. The buoy was redeployed successfully at the same location at 19:00 IST on 13 November 2010.

Recovery of Cone-head Buoy (INCOIS)

Towards the set-up of a Bay of Bengal Climate observatory in northern BoB, INCOIS had deployed a cone-head buoy with subsurface sensors at 18.0N, 89.5E on November 9, 2009. This buoy was recovered successfully, one year after its deployment, during present cruise on 7 November 2010. Buoy was cited visually at 08:00 IST, but recovery operation could start only after 10:00 IST due to heavy rains and winds associated with passing cyclone 'JAL'. Once the wind speed reduced, a small boat was lowered from the vessel. The buoy was released from the anchor weight using acoustic pulses sent to acoustic release. In a similar way to RAMA buoy retrieval, the buoy was hooked with a rope and floating body brought to the main deck using A-frame and deep sea winch. All the subsurface sensors (1 SST at 1 m, 1 upward looking DVS at 5 m, 6 MicroCats at 4 m, 7 m, 15 m, 25 m, 50 m, 100 m) were recovered one by one as the nilspin cable was pulled up by the winch. Finally the nylon rope was also recovered up to the acoustic release system. One sensor (Microcat at 4 m depth) was found damaged after recovery. All other sensors recovered in good condition. Retrieval operation got over by 19:00 IST on 7 November 2010.

Deployment of NIOT Data Buoy (BD01, BD02, and BD03)

Data buoy developed at NIOT are used to measure surface meteorological parameters, currents in upper layer of the ocean, and wave parameters. Three such data buoy (BD01, BD02, and BD03) were deployed and one buoy (MB12) recovered in the Bay of Bengal during this cruise. Deployment method for these buoys is almost similar to RAMA buoy deployments except in data buoy there are no subsurface sensors clamped on the mooring line. The floating body of the buoy was first assembled on the deck and sensors were mounted on the top tower of the buoy. Sufficient length of the nylon rope was passed from bottom of float (kept near the Wet lab starboard side) to the ship aft along the starboard boundary of the vessel. The buoy float was then lifted using the starboard crane and deployed from the starboard side. Nylon rope passing to the buoy was transferred to the big reel of about 2500 m kept below the A-frame at stern. After required length of nylon was paid out, the heavy anchor weight was attached to the mooring line and dropped using deep sea winch and A-frame at given position.

Details of deployments/retrieval of NIOT Data Buoy,

Buoy No.	Operation	Longitude	Latitude	Date	Time
BD01	Deployment	89° 40.00'E	18° 10.00'N	08.11.2010	1400 IST
MB12	Retrieval	90° 04.73'E	18° 09.18'N	08.11.2010	1900 IST
BD02	Deployment	89° 44.00'E	17° 58.00'N	09.11.2010	1430 IST
BD03	Deployment	88° 00.00'E	16° 30.00'N	11.11.2010	1720 IST

CTD operations:

Conductivity, Temperature, and Depth (CTD) casts were made up to 2000 m depth at all the locations where buoys were deployed/recovered and Argo floats were deployed. In addition, CTD (2000 m) was made at 83.0E, 11.5N during onward cruise on 29 October 2010. Time series of CTD up to 500 m depth at every 3 hourly intervals for a period of 24 hours was carried out from 2100 IST on 9 November to 2100 IST on 10 November at location 18.0N, 89.5E. During the return cruise from 12.0N, 90.0E, CTD casts were made at every 0.5 deg longitude along the cruise route depending on the bathymetry.

Note:

The condition of CTD cable was not good for deep casts. The cable was rusted and weak in many places. In the beginning of cruise, this fact was informed by Mr. Biju of NORINCO. At the first CTD station (83.0E, 11.5N) itself, the CTD cable got twisted and outer wire-mesh of cable got broken. CTD instrument was immediately recovered on the deck. Cable was thoroughly inspected for its strength and it was found that cable got heavily rusted (corrode), get permanent bending if folded by hand. Therefore it was decided to cut 600 m of initial length of cable for all future casts. Later during the cruise, again the cable wires got broken off and this time 500 m of length was cut and new connections were made. Also, it was noticed that cable coiling in the drum was not proper, because of which cable get stuck (due to overlapping in drum) many times during the operation.

For the safety of CTD instrument and sensors, it is highly recommended to replace the CTD cable immediately for any CTD operations in future.

Collection of Water Samples:

Water samples were collected from 21 depths (from sea surface up to 2000 m depth), by NIO, Goa scientists at five locations in the BoB during the cruise. These water samples were collected to study various gas parameters like dissolved oxygen, nitrous oxide, methane, total inorganic carbon dioxide, and other parameters like alkalinity, nutrients, and dissolved organic carbon samples for carbon and nitrogen isotope studies. The various depths of water sample collection were 2000, 1500, 1200, 1000, 900, 800, 700, 600, 500, 400, 300, 250, 200, 150, 125, 100, 75, 50, 25, 10, 0 m. Details of five stations of sample collection are given below.

Station No	Latitude	Longitude	Total water column Depth (m)
1	08° 03. 33'	088° 58.85'	3585
2	11° 53. 50'	083° 49. 23'	3118
3	15° 00. 07'	089° 53.43'	2702
4	18° 03. 20'	089° 26. 41'	2176
5	16° 19. 23'	087° 58. 84'	2630

Zooplankton/Phytoplankton sample collection:

Apart from water samples, NIO team also collected samples of zooplankton and phytoplankton by lowering the multipurpose net (zooplankton net) up to 200 meters at all the five locations of sample collection.

XBT probes deployments:

The Expendable Bathy Thermograph (XBT) probes, 4 no., were launched simultaneously with the CTD (2000 m) at six locations by NIO, Goa participant. In addition, 14 XBT were launched at different locations in the BoB during the cruise. Details of XBT operations carried out during SK-277 are listed below.

Stn. No.	Date	Time	Latitude (N)	Longitude (E)	Depth	No. of XBT's operated
1.	28/10/2010	06:43	12° 50'	81° 00'	760	1
2.	28/10/2010	12:21	12° 21'	81° 43'	760	1
3.	28/10/2010	16:59	11° 58'	82° 16'	760	1
4.	29/10/2010	00:56	11° 30'	82° 59'	760	4 (CTD operation)
5.	31/10/2010	21:35	08° 03'	88° 58'	760	4 (CTD operation)
6.	03/11/2010	19:35	11° 55'	89° 51'	760	4 (CTD operation)
7.	05/11/2010	20:38	15° 00'	89° 55'	760	4 (CTD operation)
8.	06/11/2010	09:55	16° 00'	89° 45'	760	1
9.	06/11/2010	19:40	17° 00'	89° 39'	760	1
10.	07/11/2010	16:34	18° 00'	89° 30'	760	4 (CTD operation)
11.	11/11/2010	19:55	16° 19'	87° 59'	760	4 (CTD operation)
12.	13/11/2010	19:31	11° 56'	89° 54'	760	1
13.	14/11/2010	01:29	12° 04'	89° 00'	760	1
14.	14/11/2010	14:48	12° 11'	88° 00'	760	1
15.	15/11/2010	02:01	12° 16'	87° 00'	760	1
16.	15/11/2010	14:50	12° 25'	86° 00'	760	1
17.	16/11/2010	01:27	12° 32'	85° 00'	760	1
18.	16/11/2010	10:31	12° 40'	83° 59'	760	1
19.	16/11/2010	19:20	12° 48'	83° 00'	760	1
Total XBT's						37

Drifter deployments:

To determine sea surface currents and collection of met-ocean data in Tropical Indian Ocean, NIO participant deployed two drifter buoys (Met-Ocean, Canada make surface drifters) during the cruise at following locations.

Station No.	Date	Time (IST)	Latitude (N)	Longitude (E)	Argos ID
1.	30/10/2010	15:20	09° 44.277'	85° 59.696'	72424
2.	12/11/2010	09:20	15° 33.302'	89° 06.668'	72425

Argo Floats deployments:

The autonomous salinity and temperature profiling floats (ARGO floats), were deployed at 11 locations during the cruise by INCOIS participants. These floats first sink to 2000 m depth and then adjust their buoyancy to rise up to sea surface. While ascending in the water column, they record the temperature and salinity profile. This recorded information is transmitted to the satellite by the Argos transmitter fixed on the float. This cycle is repeated at every 5 days. Details of Argo floats deployed during SK277 are given below.

Float Serial #	ARGOS Id		Float Make	DEPLOYEMENT DETAILS			
	Hex	Dec		LAT (N)	LONG (E)	Date	Time (GMT)
5244	A77474C	102500	Webb-APEX	8°59.99'	87°14.99'	31-Oct-10	1:40
5245	A77475F	102501	Webb-APEX	10°29.98'	84°40.22'	29-Oct-10	19:32
5293	A77476A	102502	Webb-APEX	8°05.26'	89°02.63'	1-Nov-10	19:12
5294	A774779	102503	Webb-APEX	10°00.08'	89°27.06'	2-Nov-10	12:28
5295	A77478B	102504	Webb-APEX	11°52.12'	89°46.62'	3-Nov-10	18:00
5296	A774798	102505	Webb-APEX	12°58.07'	89°56.90'	4-Nov-10	6:10
5297	A7747AD	102506	Webb-APEX	15°02.27'	89°49.95'	5-Nov-10	19:08
5299	A7747C7	102508	Webb-APEX	16°15.63'	87°57.54'	11-Nov-10	18:30
5351	A7747D4	102509	Webb-APEX	18°02.58'	89°31.85'	9-Nov-10	12:33
09IND-S3-01	9A4BC6A	93446	NKE-PROVOR	17°02.31'	89°34.81'	6-Nov-10	17:00
09IND-S3-05	9A4BCAD	93450	NKE-PROVOR	9°43.55'	85°59.93'	30-Oct-10	10:04

Atmospheric aerosols and Trace gas measurements:

Following atmospheric measurements were carried out by Physical Research Laboratory (PRL) participants to study levels and variability in aerosols and trace gases over the Bay of Bengal during post-monsoon (October – November).

1. Aerosol optical depth (AOD) using MICROTOPS II sunphotometers during clear sky days.
2. Black carbon mass concentration and aerosol scattering coefficients using 7 wavelength Aethalometer and 3 wavelength Nephelometer respectively.
3. Aerosol size distribution using Aerodynamic Particle sizer (APS) and Optical particle counter (OPC).
4. Continuous measurements of O₃, CO, NO and NO₂ using Gas Analyzers.
5. Collection of air samples for the measurements of CH₄, CO, Non- Methane Hydrocarbons (NMHCS) and CO₂ at every 4 hour interval.
6. Continuous measurements of meteorological parameters alongwith lat-lon using Automatic Weather Station (AWS) and GPS.

The data was recorded throughout the cruise period along the track of cruise. This data will be used to study the radiative forcing, pollution levels and effect of transport.

Surface Meteorological and Upper air measurements:

Participants from India Meteorological Department (IMD) have taken three hourly measurements of surface meteorological parameters and sea conditions at 0000, 0300, 0600, 0900, 1200, 1500, 1800 and 2100 UTC during the cruise period. This data was then further coded using the WMO standards set for sea observations.

The upper air data was collected by launching Radiosonde RS/RW balloon flights twice daily during normal weather days and four times a day during the cyclone period. Hydrogen filled balloons were launched twice everyday for recording upper air data at 0000 UTC and 1200 UTC. Data collected was processed using RadioSonde mark-IV instruments and Data acquisition systems. This data was processed into Temp format.

During the period of movement of JAL, cyclone over Bay of Bengal, 'Intensive Observational Phase' was initiated under which RSRW (RadioSonde, Radiowaves) flights using hydrogen filled balloons were launched four times in a day. They were at 0000, 0600, 1200, 1800 UTC on 3rd and 4th November 2010. Sea observation data was collected hourly during this period.

All the meteorological and upper air data acquired during the cruise was transmitted to IMD HQ through emails daily at regular time intervals.

Difficulties/Problems faced during the cruise:

Before the sailing of vessel from Chennai, the major Crane (National Oil Well crane) got failed on 23 October 2010 at 1700 IST. Sailing of the vessel postponed due to this failure of crane. AMC engineers (NORINCO staff) inspected the National Oil well crane and found that sealing valve in the crane got fail and all the oil from top chamber got drained. Mr. Rajaraman and Mr. Biju from NORINCO visited vessel to check the Crane. For identification of exact problem, manufacturer of the crane

(Norvey) contacted through telephone and emails. After long hours of work with the crane and online discussions with Norvey based company (manufacturer), NORINCO staff could bring the projected arm of the crane in safe position on deck. Chief Officer inspected the crane and agreed for sailing after discussions with Captain. A shore crane was hired to relocate the heavy weights on the main deck so that the buoy deployment operations can be performed in absence of ship's National Oil Well crane. Finally on 28 October, the vessel could start sailing from Chennai port at 01:20 IST.

Temperature sensor of the Sea-Bird CTD got failed on 29 October. Idronaut CTD was used for another two days for making CTD casts. Later the temperature sensor of Sea-Bird was replaced with the new sensor came as a spare with the CTD. After the sensor replacement, Sea-Bird CTD was used for all future casts and collection of water samples.

CTD cable was found to be corroded and weak. Five times during the cruise, the operation was halted due to problems related with CTD cable. While two times the cable outer wire-mesh got broken, the cable got stuck in the drum once, and got twisted once during the cruise. CTD cable need to be replaced with a new cable for any future operation.

The data logger system, receiver of Radiosonde balloon flight of IMD was of old type. This receiver was not able to receive data from high altitudes and frequently gave zero readings. Moreover, the computer provided by IMD Chennai office stopped working in mid of cruise. On the request of Chief Scientist, they were provided with another computer by NORINCO to carryout balloon flight measurements during rest of the cruise.

One of the Argo float's cowl was found damaged after opening the box. The screw hole of this cowl was broken. Therefore this faulty float was not deployed during this cruise. Total number of floats deployed was 11 floats and one float was carried back to NIOT Chennai for replacement of damaged cowl.

Two days after successful deployment, RAMA buoy at 15N, 90E transmitted wrong temperature values and buoy at 12N, 90E stopped data transmission. As the functioning of these two RAMA buoy was important, it was decided to visit these buoy again and rectify sensor problems. It was found that temperature and humidity sensor shield was broken at 15N, 90E location buoy whereas complete top tower with all the sensors was broken and hanging underwater at 12N, 90E buoy. New sensors were fixed at both the locations and buoy started transmitting data correctly.

Sad demise of mother of two participants:

Two seamen brothers, Mr. Selvaraj Emayavaramban and Mr. Venkatesan Selvaraj lost their mother during sailing on the cruise. Their mother passed away on 5 November at their home in Chennai. They were very sentimental throughout the cruise and requested, through the Chief Scientist, to the Director NCAOR for an early ETA so that they can attend the 13th day ceremony, on 19 November, at their home. Director, NCAOR kindly permitted for ETA on 17th November and the two seamen could visit their home on 18-19th November. However, all the planned operations of cruise were completed successfully.

Officers' performance during the cruise:

I am happy to mention about the good work and support that our scientific team received from Officers and Crew members in this cruise. Captain A. K. Abhyankar was cooperative and supportive by nature. He agreed with our scientific requirements and took action accordingly. I was impressed with the good work by Chief Officer, Mr. Satheesh during cruise SK-277. He has manoeuvred the vessel nicely to satisfy our needs during buoy retrieval and deployment operations. Also, he was careful about the cable and rope to avoid any entangle with ship's propeller. I appreciate the good work done by Chief Officer. Chief Engineer was also cooperative and present whenever required for any technical help. Food and catering facilities were excellent in this cruise. The dining hall was nicely decorated to create a good environment in scientist mess hall. I appreciate Catering Officer, Mr. Amitabh for his creative work and supplying good and healthy food to scientists. Medical Officer, Electrical Officer and Purser Officer also performed their duties satisfactorily.

Summary of the Scientific works done during cruise SK-277:

1. Three RAMA buoy were recovered and redeployed at 8N, 89E; 12N, 90E; and 15N, 90E locations in the Bay of Bengal.
2. One cone-head mooring Buoy (INCOIS buoy) with subsurface sensors recovered successfully from 18.0 N, 89.5 E location.
3. Three NIOT Data-Buoy (BD01, BD02, and BD03) deployed at 18.16 N, 89.66 E; 17.96 N, 89.73 E; and 16.5 N, 88.0 E.
4. One data Buoy (MB12) retrieved from 18.15 N, 90.06 E.
5. Total 11 Argo floats (autonomous temperature and salinity profiling floats) deployed at different locations along the cruise track.
6. Conductivity-Temperature-Depth (CTD) profiles up to 2000 m depth taken at every Buoy deployment/retrieval location and Argo float locations.
7. 4 Expendable Bathythermograph (XBT) probes simultaneously launched along with CTD at six locations.
8. Two drifter buoy deployed during the cruise.
9. Measurements of concentration of atmospheric aerosols, black carbon, trace gases (including CO, Ozone, NO_x) along the cruise route carried out throughout the cruise period.
10. Water samples collected from 21 depths up to 2000 m using CTD sampling bottles at 5 locations in the Bay of Bengal.

11. Zooplankton and Phytoplankton samples collected from 200 m depth at five locations during the cruise.
12. Three hourly meteorological observations carried out throughout the cruise period.
13. Radiosonde (RS/RW) balloon flights launched twice daily during normal weather conditions and four times a day during the period of cyclone 'JAL'.

Acknowledgements:

I, on behalf of the scientific team of cruise SK-277, would like to thank Shri Rasik Ravindra, Director, NCAOR for providing the research vessel 'ORV Sagar Kanya' and all the facilities onboard for our operations in the Bay of Bengal. I sincerely thank Master, Sagar Kanya for his support during cruise. I acknowledge Chief Officer, Chief Engineer and all Officers and crew members onboard for their cooperation and good work throughout the cruise. I am also thankful to Dr. M. Ravichandran, INCOIS and Dr. R. Venkatesan, NIOT for their kind support and valuable suggestions. I am grateful to Dr. Anil Kumar, NCAOR and Mr. M. M. Subramaniam, NCAOR for all the administrative and logistic support during the cruise. I sincerely thank agents Mr. Glorio Fernandis, Mr. Rajan, Mr. Venkat and their team for doing all the paper works in-time during Signon and Signoff process. Thanks are also due to the NORINCO (AMC) engineers for their untiring works during buoy and CTD operations. Finally I would like to thank all the members of scientific team of SK-277 to make this cruise successful.

Date: 25 November 2010

(Dr. Vimlesh Pant)
Chief Scientist, SK-277