

SAGAR KANYA CRUISE IN BAY OF BENGAL (SK 326)

23 January - 08 February, 2016



5th Research Cruise under
Ocean Mixing and Monsoon (OMM) Experiment

Acknowledgement

We thank the Ministry of Earth Sciences (MoES) and the National Monsoon Mission Directorate for their leadership and sustained support of the Bay of Bengal observations under the multi-institution programme “Ocean Mixing and Monsoon (OMM)”. We acknowledge MoES and the Vessel Management Cell at NCAOR for ship time on the *Sagar Kanya*. Special thanks to Captain M. D. Sanap, the officers and crew for their superb co-operation that enabled all successful operations during this cruise.

We acknowledge with gratitude the teams at SAC and INCOIS for regularly sending analyses, forecasts, satellite imagery and mooring data to the *Sagar Kanya*. We thank the NORINCO engineers and NCAOR assistant for their help throughout. Mr. Jeff Lord and Mr. Emerson Hasbrouck were helpful by giving regular lectures and familiarization talks to the science party. The four seamen Kirupa, Subramaniam, Narayanan and Thivakar were instrumental in the success of all onboard science activities. This cruise also outlined the clear generational change that is undergoing in our research field as the oldest science crew member was only 37 year old. We thank all the younger participants from various institutions for their enthusiasm and cheerfulness.

On a personal note, the young chief scientist feel privileged to lead such a good science team and to become part of the glorious tradition of *Sagar Kanya*.

Thanking you all

B. Praveen Kumar
Scientist, INCOIS & Chief Scientist SK326

Cruise Summary Report

Ship Name		ORV Sagar Kanya			
Cruise Start Date (dd/mm/yyyy)		23/01/2016			
Port of Departure		Chennai Port			
Name of Chief Scientist		B Praveen Kumar Scientist C, INCOIS, Hyderabad			
Objectives of the cruise		a) WHOI mooring recovery b) NIOT 3 mooring operations c) Lagrangian float deployment & recovery d) Argo floats & drifter proto type deployment e) Extensive uCTD & ADCP surveys in the northern Bay of Bengal f) CTD cast at selected locations & water sampling.			
Details of the Project					
Project Name		Sponsoring Agency		Principal Investigators	
Coupled Physical Processes in the Bay of Bengal and Monsoon Air-Sea Interaction		Ministry of Earth Sciences, Govt. of India		Dr. M. Ravichandran, INCOIS, Hyderabad	
		Coordinating Agency		Prof. Debasis Sengupta, IISc, Bangalore.	
		INCOIS, Hyderabad IISc, Bangalore			
Details of Date collected					
Discipline	Instrument operated	Make and Model	Parameters measured	Number of Stations	Depths of observation
Physical Oceanography	a) uCTD b) ADCP c) CTD with DO	a) Ocean Science b) Teledyne RDI c) SeaBird	a) T, S, P b) Current velocity c) T,S,P and DO	a) Continuous b) Continuous c) Continuous	a) Upto 130m b) Upto 50m c) 100m & 800m
Meteorology	a) ASIMET b) INCOIS AWS	a) Star Engineering b) Swan Environmental Tech	a) Air T, Humidity, winds, shortwave and longwave radiation b) - do -	a) Continuous throughout cruise b) Continuous throughout cruise	a) Upto 20m above surface b) -do-

Deployments/Retrievals	a) Seven APEX Argo floats deployed b) One proto-type drifter from INCOIS deployed c) WHOI & BD11 retrieval d) BD11 deployment
Quality controlled / Post processing done onboard (Yes/No)	No
Any other information	

(B. Praveen Kumar)
Chief Scientist, SK 326

Date : February 08, 2016
Place : Chennai

Sagar Kanya Cruise, SK 326

23 January - 08 February, 2015

Sagar Kanya started sailing from Chennai port from 23rd January on a 17 day cruise. Total science crew in this cruise (SK 326) is 21 which include scientists and students from several Indian research labs and academic institutes. Mr. Jeff Lord and Mr. Emerson Hasbrouck of Woods Hole Oceanographic Institute (WHOI, USA) also participated in SK 326 for a WHOI mooring recovery which was deployed in November 2014 in a Sagar Nidhi cruise.

1. Objectives and Cruise Outline

SK 326 is the 5th cruise under the Ocean Mixing and Monsoon (OMM) program, the other four were conducted onboard Sagar Nidhi (SN 82, SN88, SN 14/2014, and SN100). Main objectives of the 17 day cruise are

- a) Recovery of the Woods Hole Mooring
- b) Extensive upper ocean survey of the Northern Bay of Bengal
- c) Deployment & Recovery of Lagrangian float and deployment of argo floats
- d) NIOT's 3 mooring operations (Deployment & Recovery of BD11 and Recovery of ITBS).

Our initial plan was to identify an eddy structure outside the Indian EEZ for the deployment of Lagrangian float and then proceeding towards WHOI mooring location for recovery. On this track, which is in international waters, we decided to deploy 7 argo floats (3 bio argo and 4 standard argo floats). Just before the cruise, we identified a downwelling eddy centered at around 14°N,86°E and gave that position as the first way point to the ship bridge.

Soon after we left Chennai Port, one of the main propulsion motors failed, resulting in a significant reduction in the ship's speed. This prompted us to re-think our plans with the Lagrangian float operations since if the float drifts south or east, it would be difficult to recover the float at the end of the cruise considering the slow speed of the ship. Hence that plan was dropped. We followed the same track, but once crossed the EEZ, then proceeded directly to WHOI mooring location. On this track we deployed 7 argo floats. We recovered the WHOI mooring on 29th January. The whole operation took 7 hours.

After the WHOI operation started our adaptive phase of the cruise. Cruise track was decided based on the real-time information we got from satellite and forecast models. Real-time satellite images received from INCOIS ground station and Space Application Centre (SAC) were helpful

in taking decisions. In this phase of the cruise, we started to survey the upper ocean using the under way CTD system (uCTD) and pole mounted ADCP. Science crew was grouped into 4 teams and each team worked on 6 hour shifts. We started sailing northward of the WHOI mooring position and did a long east-west survey along 20°N and then a survey along an inclined track along south-east. This phase of the cruise lasted for 3 days.

On the late hours of 1st February, we stopped our survey in the northern Bay and started sailing towards the BD11 location for mooring operations. We reached the BD11 position (13.5°N, 83° 57'E) at 12:30 hrs and started the recovery operation by 13:10 hrs. The whole operation lasted for 4:30 hrs. The deployment of the BD11 was planned for the next day (5th Feb). NIOT engineers identified an issue with their mooring system on 5th morning. Though they tried their best, it was only solved that day evening. Hence we decided to deploy the mooring on the next day. On 6th Feb, we started the mooring operation by 09:00 hrs, and it was over by 12 noon. While doing the BD11 recovery operation, the nylon rope from the mooring line unfortunately got stuck at the bow thruster of the ship and damaged the DP system. Since the DP is not working, we decided not to recover the ITBS mooring. After the BD11 deployment, we started sailing back to Chennai port at 17:00 hrs of 5th Feb. We reached Chennai port on 8th February morning.

2. Cruise track, Operations and Timeline

2.1 Cruise track

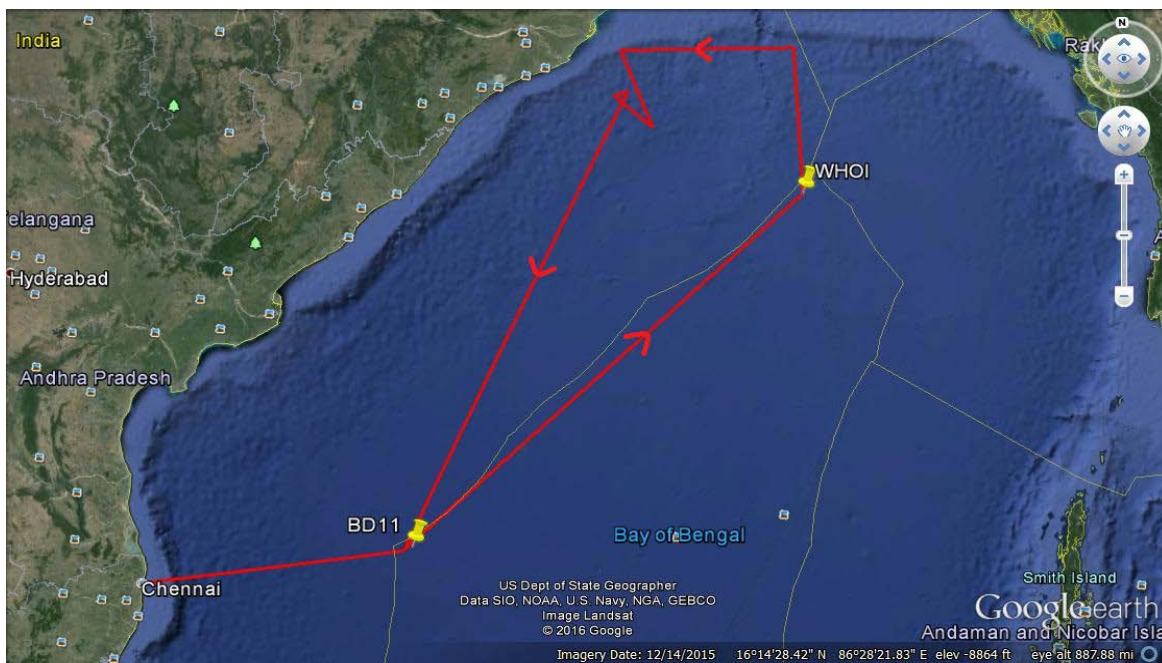


Figure 1: Cruise track of SK 326

2.2 Operations

2.2.1. WHOI mooring Recovery

We reached the WHOI mooring position of 18°N,89°27' on 28th evening 20:00 IST and stationed upwind of the anchor position. Upon arrival, we did a deep CTD cast of 1000m, and sampled water from different depths. On 29th morning, ship maneuvered further close to the buoy and lowered the transducer by 06:15. There were some initial hiccups in the communication with the acoustic release, but were successful after few attempts. The yellow glass balls were surfaced at 07:05 hrs. Ship position was further adjusted such that the glass balls and the buoy were in the downwind direction. Then the Gemini boat was lowered with two seamen and Mr. Emerson (from WHOI) and they connected the pickup lines to the balls. By 07:55, all the 52 yellow glass balls were taken into the deck using the A-Frame and the capstan. The small boat was on the deck by 08:00 hrs.

By 08:15, using Atlas crane and capstan, recovery of the mooring line and instruments attached to it, were started. This was continued up to the top 50m of the mooring line were taken off. Then the buoy was sent adrift. Small Gemini craft was again sent to attach the working line with the buoy, and it was attached to the main National Oilwell Crane. The buoy was then pulled up in air and let it spin for some time. Tag lines were then attached to the buoy and lifted high to swing in. A stopper was then attached to the mooring line and detached it from the buoy. By 12:00, the buoy was secured into the deck. All the instruments attached to the top 50m of the mooring line were then recovered using the crane. After that, the Gemini craft was recovered. By 12:15 the whole buoy operation was over.





Figure 2: from top right: TR: WHOI mooring sighted, TL: deck operations in full swing to recover the yellow glass balls, BR: Establishing working line with the buoy for the recovery and BL: recovering the buoy.

2.2.2. Argo deployments.

A total of 7 argo floats were deployed during this cruise. The details of the argo floats deployed and its locations are given in the table below:

Sr. No	Float ID	Model Name	Deployed at		Deployed on
			Latitude	Longitude	
1	7497	APEX-APF91	13° 22' N	83° 51' E	25/01/2016 15:05 hrs
2	7548	APEX-APF91	13° 59' N	84° 32' E	26/01/2016 00:57 hrs
3	7558	APEX-APF91	14° 28' N	85° 45' E	26/01/2016 08:28 hrs
4	7547	APEX-APF91	14° 59' N	85° 39' E	26/01/2016 16:00 hrs
5	7557	APEX-APF91	15° 30' N	86° 16' E	27/01/2016 01:32 hrs
6	7556	APEX-APF91	15° 58' N	86° 35' E	27/01/2016 12:56 hrs
7	7545	APEX-APF91	17° 29' N	88° 48' E	28/01/2016 11:45 hrs

2.2.3. uCTD and ADCP survey in the northern Bay of Bengal

We collected temperature and salinity from Thermosalinograph throughout the cruise. Intense survey of the upper ocean structure north of 18°N started on 29th February evening after the WHOI mooring operation. This allowed us to make a direct comparison of Thermosalinograph T/S fields against the surface values from the uCTD. We found a warm bias of 0.25°C in the Thermosalinograph temperature. Salinity from both the instruments was matching well.

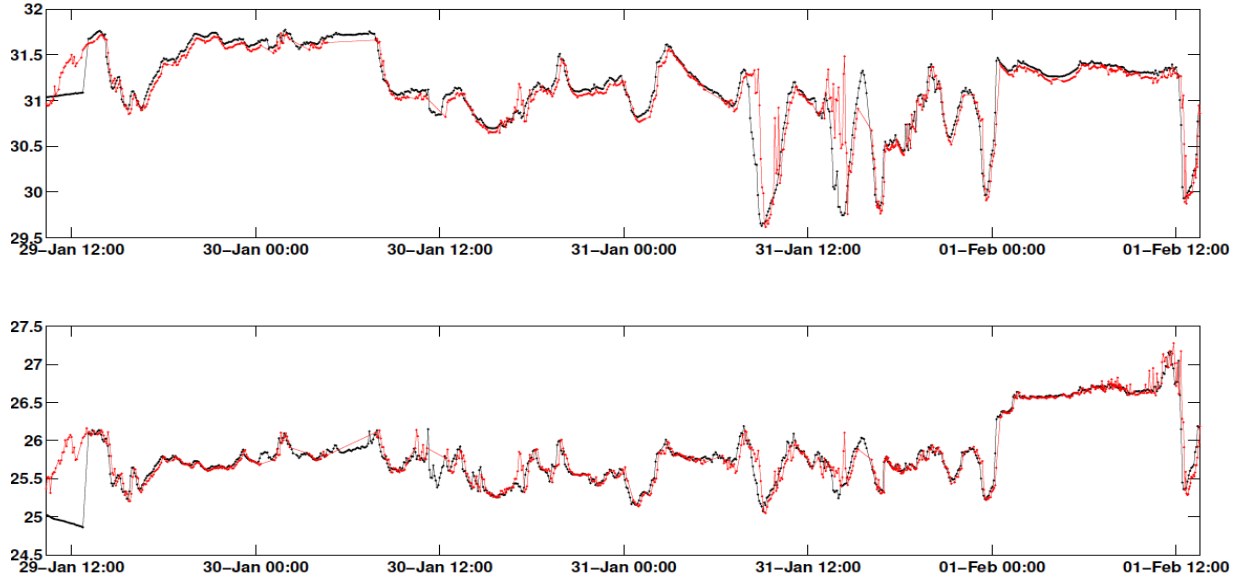


Figure 3: Salinity (top panel) and Temperature (bottom panel) comparison between Thermosalinograph (black lines) and 4m depth uCTD (red) values. Thermosalinograph temperature values are corrected for the warm bias compared to uCTD values.

A total of 806 uCTD profiles were collected over 663 km length track. Mean sampling interval is 5 minutes and spatial resolution is 0.8 km. Real time satellite sea level anomalies suggest that along 20°N, we were moving from a strong downwelling eddy to a strong upwelling eddy. uCTD observations suggest that in the subsurface layers of the downwelling eddy strong thermal inversions (also known as the barrier layers) of more than 2°C were prevailing. The thickness of these barrier layers were upto 40m between 30-70m layers.

We crossed over from the downwelling eddy to the upwelling eddy at around 87.5 longitude along 20°N latitude, which marked upsloping of the isopycnal contours. Over the upwelling eddy, the thermal inversions are very weak and confined more to the surface layers. Over the course of our upper ocean survey, we crossed many strong frontal structures with spatial density gradients ranging from 0.4kg/m³ to 1kg/m³ over distances of 4km to 15 km.

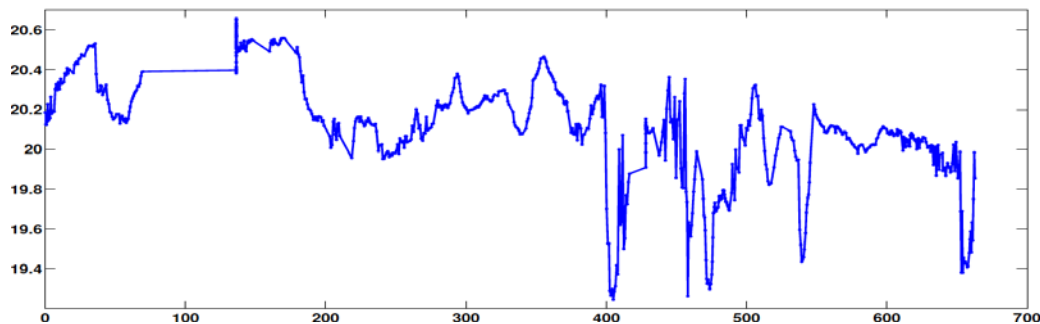


Figure 4: 4m density from the uCTD observations along the ship track.

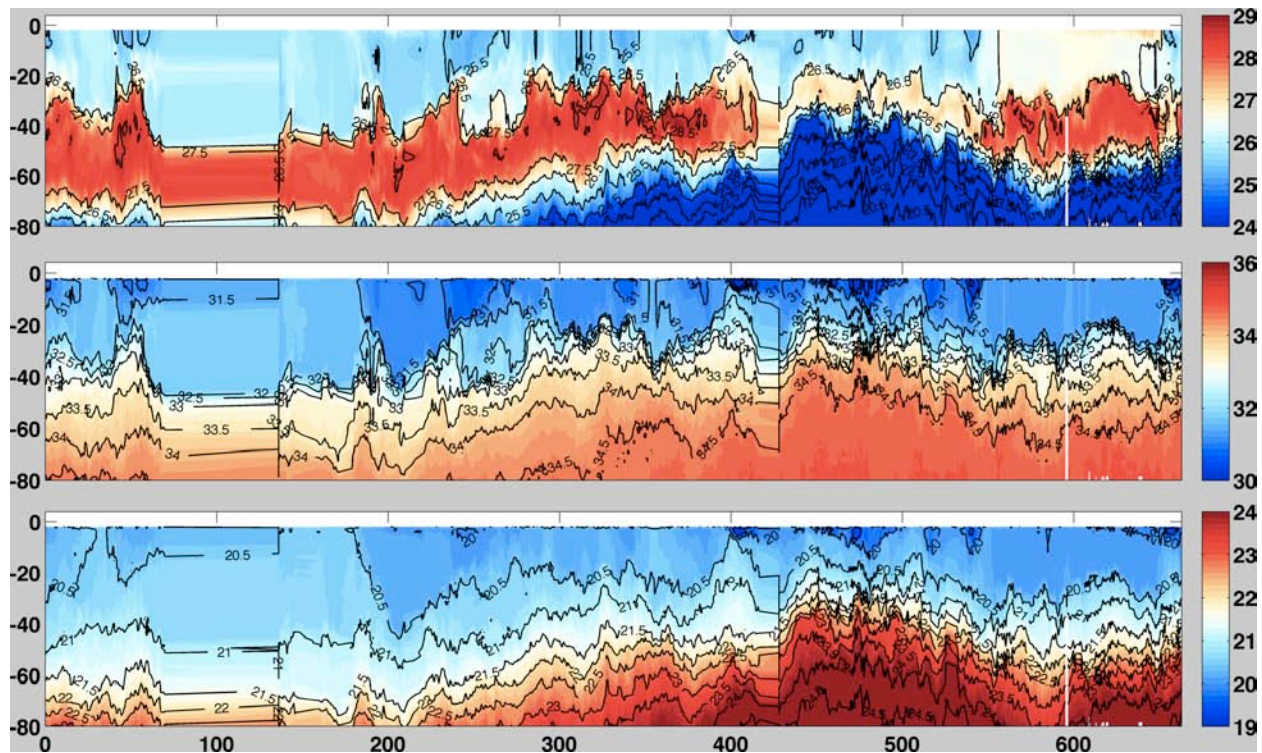


Figure 5: Along track sections of temperature (top panel), salinity (middle panel) and density (bottom panel) from uCTD observations.

2.2.4. BD11 mooring operations

We reached the BD11 mooring location ($13^{\circ}30'N$, $83^{\circ}57'E$) at 12:30 hrs of 4th February and sighted the buoy. Mooring recovery operations started by 12:45 hrs. Benthos made Deck box of the acoustic release that NIOT uses was not working for some reasons. But the ORE Deck box that WHOI used for their operation was compatible with the Benthos release and used it to release the mooring. Yellow and green glass balls were surfaced and sighted at 13:00 hrs. Then Mr. Ramesh from NIOT and a seaman went in a Gemini craft to establish a working line with the buoy. Boat was then taken back to the deck and started to pull the buoy using A-frame and the capstan. At 14:00 hrs the buoy was taken into the deck, and started to pull in the cable and instruments attached. When the nylon ropes were taking in, it was noticed that the remaining line was going below the ship. Soon it realized that the rope is cut off and the yellow glass balls and the acoustic release mechanism were sighted at some distance. By that time, Ship bridge informed that the ship DP system is not working, suggesting that the nylon rope must have entangled with the bow thruster and got cut off. Mr. Ramesh and a seaman again went in a small boat to secure the remaining portion of nylon rope. Acoustic release and the yellow balls were taken into the boat 17:30 hrs. Deployment of the mooring was planned for the next day.



Figure 6: NIOT engineers trying to establish a working line in the BD11 buoy (right panel) and the BD11 buoy onboard (left panel).

On 5th February morning, NIOT engineers detected some technical snags with their mooring system. They tried to solve the problem but were not successful till the evening. Hence the deployment operation was postponed to 6th February.

NIOT engineers rectified the issues by 6th morning and started deck work for the deployment by 09:00 hrs in the morning. Ship was lined in the upwind position and the buoy was deployed at 09:45 hrs using the A frame. The induction communication cable connected with the buoy was then fitted with subsurface sensors and started to pay out from the deck. Dead weight was dropped at the anchor position by 11:45 hrs and thus completed the deployment work. We remained at the BD11 location for another couple of hours for checking the first transmission from the buoy. Once we got confirmation from the shore team from NIOT that all the systems are working well, we started sailing to our next destination.

2.3. Timeline and Daily activities:

22/01/2016

All scientific materials were loaded into the ship and science crew signed on by 16:00 hrs. But since provisioning in the ship and some welding work required for the science activities during this cruise were pending, it was decided to start the cruise next day. Confirmation from this regard was received from NCAOR.

23/01/2016

Ship started sailing on January 23rd, 2016 at 15:30 hrs from Chennai Port. ASIMET modules were assembled on a bow mast. Discussed with master about the cruise plan, and first way point for the Lagrangian float deployment was given to bridge.

24/01/2016

A few hours after leaving the Chennai port, one of the propulsion motors failed. As a result, the ship speed was reduced to less than 5nm/hr. This resulted in a re-thinking in our planned cruise activities. Lagrangian float deployment was cancelled since it might not be possible to retrieve the float at the end of the cruise if the float drifts south or east. It was decided to cross the Indian EEZ and then proceed towards WHOI mooring location, as it allows us to deploy the argo floats in international waters.

In the morning, uCTD was fitted in the port side stern. A training on the basic uCTD operations procedure was given by Mr. Shivaprasad to the Science party at 16:00 hrs.

25/01/2016

Argo float pre-deployment tests were done in the morning. Ship crossed EEZ at 12:00 hrs, and stopped at 13.5°N,84°E for a CTD station. CTD of 100m started at 13:10 hrs and ended at 13:35hrs. A load test was done between 13:40-14:00 hrs on the A-frame to check for its preparedness before the WHOI mooring operation. A standard argo float was deployed at this location and the ship started sailing towards the WHOI location.

At night 20:00 hrs, a cruise meeting with Captain, other officers and science crew was conducted. Mr. Jeff Lord briefed about this plans for the WHOI mooring recovery. Meeting was over by 21:00 hrs.

26/01/2016

Ship continued to sail northward towards the WHOI location. In the morning 09:00 hrs, national flag was hoisted to celebrate India's Republic Day.

Three argo floats were deployed on 26th on the ship enroute; One standard argo float at 13°59'N,84°32'E at 00:57 hrs, one bio argo at 14°28'N, 85°45'E at 08:28 hrs and another standard

argo float at 14°59'N,85°39'E at 16:00 hrs. CTD cast and water sample collection were done at all argo locations. A prototype drifter from INCOIS was also deployed at the 3rd argo location.

27/01/2016

We are on our way towards WHOI mooring location. Two bio argo floats were deployed today; one at 15°30'N,86°16'E at 01:32 hrs and another at 15°58'N, 86°53'E at 12:56 hrs. CTD casts were done and water samples were collected at all the argo locations. Another CTD cast was done 16°39'N, 87°31'E at 20:45 hrs. But due to mechanical failure of the CTD winch, we failed to do the CTD cast and water sample collection, and finally managed to manually pull the CTD into the deck. Requested the ship engineers to rectify the issue before the next station.

28/01/2016

The last argo float was deployed today at 17°29'N,88°48'E at 11:45 hrs. Ship reached the WHOI mooring location by 19:00 hrs and sighted the buoy. A pre-recovery meeting with the science crew was conducted between 20:00-20:30 hrs to discuss the individual responsibilities of the science crew members during the WHOI mooring operation. By this time, ship engineers rectified the CTD winch problem, and a winch test was done at 20:45 hrs which was a success. A deep CTD cast up to 1000m was done after that between 21:20-22:25 hrs. Ship was in DP in the upwind direction of the buoy throughout the night.

29/01/2016

We started the WHOI mooring recovery from 06:00 hrs, and the whole operation was over by 12:30 hrs. A CTD for 100m was done. After lunch, lowering of the pole mount ADCP started, which was over by around 15:00 hrs. All the uCTD set-ups were checked once again, and the ship started sailing towards 20N by 16:00 hrs at 5 knots speed. This started our intense survey of the northern Bay of Bengal for the next couple of days.

30/01/2016

We continued sailing north and stopped at 11:00 hrs for downloading the checking the ADCP data. A ctd cast up to 100 m was done and water samples from 100m and surface were collected. The whole operations took close to two hours and we started sailing northward toward 20°N by

13:00 hrs. Once reached 20°N, we changed our course towards west for a long east-west section and followed the 20°N line. At 20:00 hrs Mr. Emerson gave an interesting hands on training on how to use SBE 37 temperature sensor. The training was very informative and encouraging.

31/02/2016

We are still continuing our way towards west doing intense upper ocean survey using uCTD and ADCP, and the next destination is 20°N,87°E. High resolution SST images obtained from INCOIS suggest that there is a sort of thermal front south of that location. At 11:00 hrs, we stopped for a CTD cast at 20°N,87°55'E and water samples were also collected. NIOT engineers started assembling their buoy from the evening. uCTD & ADCP operations started soon after the ship started sailing towards west. Mr. Emerson gave a familiarization class on how to use the RBR SoloT and SBE 39 probes at 20:00 hrs.

01/02/2016

uCTD & ADCP surveys continued. Early morning (12 noon - 6 am) uCTD team crossed some strong T/S fronts. These observations were in agreement with the satellite images received from INCOIS. Then it was decided to change the course of the ship and make sections again across the same front. Throughout the day we sailed north-westward hoping to re-trace the front that we saw in early hours of the day. But our efforts were futile. It was decided to stop the uCTD surveys by the evening. A closer examination of the satellite SST image suggests that we might be moving along the frontal boundary. So after 18:00 hrs, the ship course was further changed towards north-eastward. surprisingly we found a sharp gradient in SSS of 1.3 psu within 5 nm of changing the course. Once we crossed the front, we stopped the uCTD operations at 19:00 hrs. A CTD cast and water sampling was done at the location. At 20:30 hrs we started our way back to NIOT's BD11 buoy location.

02/02/2016

We are sailing on our way to BD11. No other operations onboard. NIOT technicians finalizing preparations for their buoy operations. As usual in these days, Mr. Emerson gave a hands on training on Aquadopp/Aquapro instrument.

03/02/2016

On our way to BD11. No operations onboard. NIOT team's preparations for their mooring on full swing. Today Mr. Emerson selected RDI ADCP for his night class.

04/02/2016

We reached the BD11 location (13°30'N, 83°57'E) in the afternoon by 12:30 hrs and sighted the buoy. NIOT engineers started preparations for the recovery of the buoy. Recovery operation is over by 17:30 hrs.

Ship's DP system was damaged possibly due to nylon rope of the mooring got entangled in the bow thruster of the ship. Since the DP system is not working, it was decided to cancel the Tsunami mooring operation. BD11 buoy deployment was planned for the next day.

05/02/2016

Today morning, NIOT engineers noticed some technical issues with their buoy set-up. Several back and forth e-mails were exchanged between NIOT crew members and their shore control team, but the issue was not satisfactorily solved. So in the afternoon it was decided to postpone the deployment to the next day. Ship was drifting around the BD11 location the whole day.

Mr. Emerson gave a familiarization class on the ASIMET ship modules between 10:00-12:00 hrs, which was very informative and interesting.

06/02/2016

All the issues with the buoy system was solved the previous night. Deck preparations for the mooring deployment started from 09:00 hrs in the morning. The buoy operations started from 09:30 hrs and got over by 12:00 noon. We stayed at the mooring position for couple of hours for the next transmission from the buoy which was at 14:30 hrs. At 15:00 hrs, NIOT's shore team informed that the mooring is working satisfactorily. We started taking down the ASIMET modules fitted on a bow mast of the ship by 15:30 hrs. The whole cruise plan is over by now, and we started sailing back to Chennai at 16:30 hrs. Expected ETA at Chennai is at 04:00 hrs of 8th Feb.

In the evening at around 17:00 hrs, Chief Scientist organized a party for the science team and officers for celebrating the successful completion of the cruise. It was a bright, star studded sky, perfect for a night party. Whole team celebrated by singing and dancing and mingling with all others. Party got over by 21:00 hrs.

07/02/2016

Packing of the materials on full swing. A photo session was organized at 09:30 hrs. Revised ETA at Chennai port at 09:00 hrs.

08/02/2016

We reached near Chennai port. Once we are at 50m bathymetry at 07:30 hrs, we stopped the ship and the ADCP pole was lowered for bottom tracking. We made 1 nm north track and then another 1 nm west track. Pilot came at around 09:30, and the ship was berthed by 10:15. Emigration formalities were over by 12. Offloading of materials started by 14:00 hrs and science crew signed off at 15:30 hrs.