

Sagar Nidhi Cruise, SN 144

17 September - 10 October, 2019

Sagar Nidhi started sailing from Chennai port from on 18th September 2019 on a 22 day cruise. Total science crew in this cruise (SN144) is 18 that include scientists and students from Indian National Center for Ocean Information Services (INCOIS, Hyderabad), Indian Institute of Technology (Madras and Kharagpur) and Andhra University.

1. Objectives and Cruise Outline

SN144 is a research cruise funded by Ocean Observation Network (OON) program of Ministry of Earth Sciences (MoES, Govt. of India), implemented by INCOIS, Hyderabad. Main objectives this cruise are

- a) sample the upper ocean small scale turbulent characteristics using Vertical Microstructure Profiler (VMP) at different stratification regions of Bay of Bengal, and its dependence on eddy characteristics
- b) Intense sampling at the INCOIS flux mooring location using VMP, Lowered ADCP (LADCP), underway CTD (uCTD), and water sample measurements. Four hour repeated VMP casts near the flux mooring is planned to understand the vertical distribution of small scale turbulent mixing near INCOIS Flux mooring. uCTD measurements are planned at four corners around the flux mooring and LADCP measurements near the mooring to estimate the mixed layer heat and salt balance at finer timescales (~hourly)
- c) To collect biogeochemical measurements at different stratification regions and also as a timeseries near INCOIS flux mooring.
- d) 4 days of intense sampling of a 20 km long section near Paradeep to understand the internal tide characteristics of the region.

Our cruise had three different phases. In phase one, we covered a south-north transect in the Bay and took measurements at morning 5PM and evening 5 PM. Measurements included VMP and portable CTD casts, and water sample collections. In the second phase, Sagar Nidhi was located near INCOIS flux mooring and took measurements around it. In the final phase of our cruise, we stationed near Paradip and sampled a 20 km coastal stretch to study internal wave dynamics and generating mechanisms.

2. Cruise track, Operations and Timeline

2.1 Cruise track

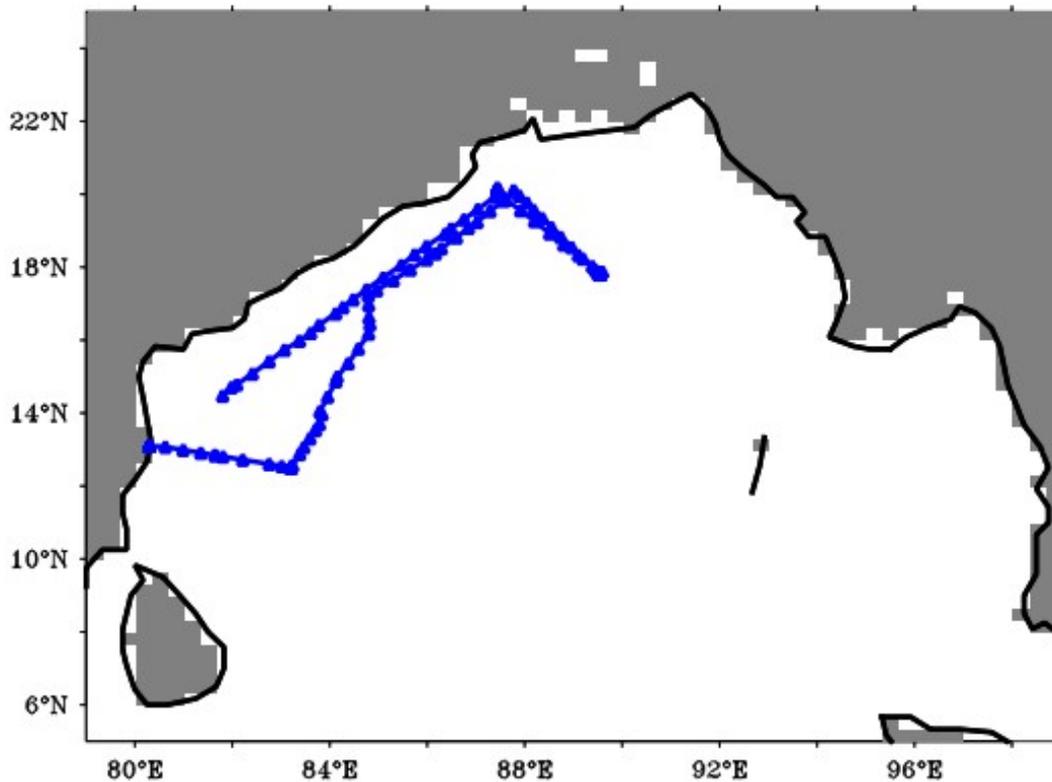


Figure 1: Cruise track of SN 144

2.2 Operations

2.2.1. VMP and LADCP transect

This experiment was planned to collect mixing characteristics in a south-north transect in the Bay covering high saline southern part and low saline northern Bay. A one day timeseries was done in southern most point. The stations were planned to cover sections along eddies in the eastern part of the Bay. Ship was stopped at morning 5 AM and evening 5 PM to collect data. In the morning stations, VMP profiles, LADCP, portable CTD, radiometer and zooplankton samples were collected. In the evening stations, radiometer operations were not done due to less sunlight, but other measurements were obtained.

2.2.2. Biological observations.

The primary objectives of the biology team participating in the SN-144 cruise were 1) to make biological observations along the transect and at the time-series stations, and 2) to train the team-

members in doing so. To meet the latter, it was ensured that the team members were rotated so that every member gets to perform all the related tasks for every instrument deployed/observation taken.

The cruise plan was set to address the physical oceanography team science hypothesis. Biology team conducted observations opportunistically as and when permitted. The team carried two instruments viz., hyperspectral radiometer and portable CTD. In addition, the team made use of onboard facility of zooplankton net and CTD-Rosette system to collect seawater samples. In order to compliment the dissolved oxygen (DO) data from both the CTD systems, water samples were collected for the DO analysis at certain stations. Additionally, seawater samples were collected for phytoplankton, pigments and nutrients. These samples were collected at various depths for up to 200 meters. A deep-cast was conducted once to cover the depth range of 200-1000m. All the seawater samples will be analyzed in laboratory. When time-permitted, zooplankton net-tows were carried out to collect zooplankton from the surface. At time-series stations in the vicinity of INCOIS flux-mooring, surface water samples (through bucket) and zooplankton net-tows were carried out at the center and corner (north, south, east, west) stations of the time-series.

Along with aforementioned biogeochemical oceanographic observations, primary productivity experiments were conducted onboard SN-144 during daytime. A set of bags were used made of cloths that permit varying light levels inside the bags. The light levels were quantified and used uniformly across the stations. A hyperspectral radiometer profile was collected in the morning (around 09AM) to know the light attenuation at various depths at the station. Based on these data, depths were calculated for water sample collection. The radiometer operation was followed by deployment of CTD-Rosette assembly for water collection at these predefined depths. The timing of radiometer and sample collection was managed to facilitate the incubation period of three hours equally distributed on either side of the local noon time (as calculated by $\{\text{sunset time} - \text{sunrise time}\} / 2$, from the almanac). The samples were then added with stable, non-radioactive carbon (C^{13}) isotope as a tracer for the photosynthesis process. Blank (no tracer) sample and Control (with tracer) sample were also collected and filtered immediately (i.e. $t=0$) with 25mm GF/F filter papers and kept for overnight drying at 40 °C in the oven. Transparent samples bottles were kept in the cloth bags and exposed to uninterrupted sunlight for incubation. This was done by putting the bottles in a plastic crate on the deck area towards the stern. Running seawater with moderate flow was provided during incubation through fire-hose extension to avoid heating and to simulate natural at-depth sea conditions. At the end of the incubation period, filtration and oven-drying procedure were followed similar to the Blank and Control. All samples were preserved at room temperature.

2.2.3. Internal tide measurements in the shelf region near Paradip

Internal tide generation by barotropic tidal forcing on continental shelf topography is well-recognized to be a dynamically important phenomenon in the ocean. It can either result in enhanced

subsurface vertical mixing locally, or impart significant energy into far-propagating internal waves that subsequently dissipate and cause subsurface vertical mixing in the open ocean. In either case, the role of internal tide generation in the Bay of Bengal could represent a critical component of accurate modelling and understanding of various processes in the region.

A four day campaign (October 3-6, 2019) was undertaken in the continental shelf region near Paradip to perform measurements of internal tide activity, and internal tide driven turbulence. The transect that was surveyed is shown in magenta in Figure 1, and within the transect, nine different locations (at depths going from 200 m to 1000 m in steps of 100 m) were chosen as measurement stations. The following measurement instruments/techniques were deployed to achieve our objectives:

1. Multi-beam bathymetry to map the ocean floor in the region at high spatial resolution.
2. Vertical microstructure profiler (VMP) to directly measure the vertical profiles of shear associated with the small-scale turbulence. The hypothesis is that small-scale turbulence will be enhanced in regions where internal tide activity is present. Additionally, the VMP also measures the temperature and conductivity. For each profile, maximum effort was taken to lower the instrument to within 50 m from the sea floor. Due to the existing winds and currents, it was not always possible to reach the desired depths. The ship was in drift mode during the VMP operations.
3. Lowered ADCP (LADCP) to measure the vertical profile of horizontal currents at the nine different stations along the transect. The LADCP instrument was always lowered to a depth that is 50 m short of the local depth. The ship was in DP mode during LADCP operations.
4. Underway CTD (UCTD) to measure vertical profiles of conductivity and temperature along the chosen transect. The ship was moving at around 2 to 3 knots during the UCTD operations.

2.3. Timeline and Daily activities:

18/09/2019

Ship started sailing from Chennai port at 03.00 hrs in the morning.

19/09/2019

At 10.00 hrs, a trial CTD deployment was done at 12°31.04'N, 083°12.045'E location. This was followed by a 24 hr VMP time series that started at 11.15 hrs at the same location. A total of 9 VMP profiling with three hrs interval was done until 12.00 hrs noon in the next day(20/09/2019). On the same day LADCP operation was called off due to winch problem at 18.30 hrs.

20/09/2019

VMP profiling as part of 24hr VMP time series was performed between 02.00 hrs and 12.00 hrs. After the 08.00 hrs VMP profiling, portable CTD was operated at 12°30.18N, 083°12.25E. Once the VMP time series was over at 12.00 hrs, CTD was operated at 12.50 hrs and followed by zooplankton net operation. For the zooplankton net deployment ship was moving at a speed of 2 knots. The plan for next few days is to have measurements (VMP, portable CTD, zooplankton net deployment, CTD with water sample collection and radiometer at multiple locations called as way points along a transect towards north Bay of Bengal. We reached the first way point (location 12°51.95N,83°22.747E) at 17.06 hrs and completed VMP profiling by 17.57 hrs. The VMP profiling was followed by zooplankton net deployment while ship is proceeded to the next way point.

21/09/2019

We reached the way point (location 13°41.629N,83°47.400E) at 05.00 hrs in the morning and completed VMP profiling which involved 5 casts. VMP profiling was followed by portable CTD at 09.00 hrs, radiometer operation at 10.00 hrs, CTD operation with water sampling at 10.38 hrs and zooplankton net deployment at 11.20 hrs. Then ship proceeded to the next way point. Before reaching the way point ship reduces its speed to 2 knots for zooplankton deployment at 18.00 hrs. At 18.22 hrs we reached the next way point (location 14°56.201N,84°08.018E) and VMP profiling was completed by 19.46 hrs. During VMP operation, a sword fish was entangled in the VMP line but no fish bite was observed. VMP profiling was followed by portable CTD operation at 19.47 hrs and then the ship proceeded to the next way point.

22/09/2019

We reached the way point (location 16°10.784N,84°48.032E) at 05.38 hrs and completed VMP profiling by 06.47 hrs. VMP profiling is followed by radiometer operation at 09.08 hrs, portable CTD profiling at 09.30 hrs and CTD operation with water sample collection at 09.53 hrs. Zooplankton net is deployed while ship is cruising to the next way point. We reached the next way point (location 17°13.274N,84°47.760E) at 17.04 hrs and completed the VMP profiling by 18.10 hrs. VMP profiling is followed by portable CTD profiling and zooplankton net deployment at 18.27 hrs. And the ship was proceeded to the next way point.

23/09/2019

VMP profiling started at 05.43 hrs at the way point (location 18°13.219N,86°00.206E), which was then followed by zooplankton net deployment at 08.50 hrs and two radiometer operations at 09.01 hrs and 09.13 hrs. Portable CTD profiling started at 09.35 hrs and followed by CTD operation with water sample collection at 09.58 hrs. After this ship proceeded to the next way point. We reached the way point (location 19°04.270N,86°50.757E) at 17.04 hrs and VMP

profiling completed by 18.15 hrs. VMP profiling was followed by portable CTD profiling at 18.20 and zooplankton net deployment at 18.45. Ship then proceeded to the next way point.

24/09/2019

VMP profiling started at 05.05 hrs at the way point (location 20°04.516N,87°47.414E) and followed by LADCP deployment at 06.30 hrs, CTD and water sampling at 08.35 hrs and portable CTD at 08.45 hrs. Ship proceeded to the location of INCOIS flux mooring.

25/09/2019

Boat operation was planned to check the sensors in the INCOIS flux mooring. Boat operation began at 14.00 hrs and completed at 16.30 hrs. Next few days measurements were planned near the INCOIS flux mooring. For that purpose, a centre location is fixed, which is at a distance of 2.8km from the mooring and four transects are planned for measurements namely North-Centre, South-Centre, West-Centre and East-Centre. Each transect is 7km long. The mooring is positioned between West-Centre and South-Centre transect lines and transect lines are at a perpendicular distance of 2km from the mooring. The first VMP profiling for the measurement plan near the mooring location (centre point: 17°49.821N,89°32.645E) started at 17.03 hrs and completed at 18.42 hrs. It was then followed by LADCP at the same location at 18.50 hrs. Next VMP profiling started at 20.09 hrs and completed at 21.14 hrs. Ship then proceeded to the west point. Multiple uCTD profiling was done during the West-Centre transect. Another VMP profiling at the centre location started at 23.00 and completed at 00.22 hrs next day. And ship is proceeded to north point.

26/09/2019

Multiple uCTD profiling was done during North-Centre transect. VMP profiling at the centre location started at 02.06 hrs and completed at 03.08 hrs. Ship then proceeded to the South point. Multiple uCTD profiling was done during South-Centre transect. Second VMP profiling of the day at the centre location started at 04.57 hrs and completed at 06.00 hrs. This VMP profiling was followed by LADCP operation at 06.04 hrs and continued till 06.40 hrs. At the same location third VMP profiling of the day started at 08.13 hrs and completed at 09.12 hrs. This VMP profiling was followed by radiometer operation at 09.14 hrs and portable CTD profiling at 09.27. It was then followed by CTD and water sampling at 09.40 hrs. Ship then proceeded to the East point. Multiple uCTD profiling was done during the East-Centre transect. Fourth VMP profiling of the day at the centre location started at 11.15 hrs and continued till 12.15 hrs. Ship then proceeded to the North point. During North-Centre transect, multiple uCTD profiling was done. At 12.21 hrs zooplankton net was deployed when the ship was cruising at 2 knots. Fifth VMP profiling at the centre location started at 14.06 hrs and completed at 15.11 hrs. uCTD profiling during South-Centre transect was cancelled due to some technical issues. At 16.03 hrs

zooplankton net was deployed near to the South point. Sixth VMP profiling at the centre location started at 17.03 and continued till 18.10 hrs. This VMP profiling was followed by LADCP operation at 18.19 hrs. Ship then proceeded to the East point. Multiple uCTD profiling was done during East-Centre transect. And the seventh VMP profiling at the central location started at 20.14 hrs and continued till 21.19 hrs. Ship then proceeded to the West point. During West-Centre transect, multiple uCTD profiling was done. The final VMP profiling of the day at the centre location started at 23.05 hrs and completed at 00.08 hrs next day. Ship then proceeded to the North point.

27/09/2019

Multiple uCTD profiling was done during North-Centre transect. And VMP profiling at the centre location started at 01.46 hrs and completed at 02.52 hrs. Another VMP profiling at the central location started at 05.30 hrs and completed at 06.30 hrs. This VMP profiling was followed by LADCP operation at 06.38 hrs. Third VMP profiling of the day at the centre location started at 08.13 hrs and completed at 09.16 hrs. This VMP profiling was followed by CTD and water sampling at 09.25 hrs, portable CTD profiling at 10.08 hrs and zooplankton net deployment at 10.17 hrs. The fourth VMP profiling at the centre location started at 10.54 hrs and completed at 11.55 hrs. Ship then proceeded to the North point. Multiple uCTD profiling was done during the North-Centre transect. The fifth VMP profiling of the day at the centre location started at 13.40 hrs and continued till 14.47 hrs. Ship then proceeded to the South point. During South-Centre transect multiple UCTD profiling was done. The sixth VMP profiling at the centre location started at 16.49 hrs and completed at 18.00 hrs. This VMP profiling was followed by LADCP operation at 18.10 hrs and zooplankton net deployment at 19.05 hrs. Ship then proceeded to the East point. During East-Centre transect multiple uCTD profiling was done. The final VMP profiling of the day at the centre location started at 23.24 hrs and completed at 00.41 hrs next day. Ship then proceeded to the North point.

28/09/2019

Multiple uCTD profiling was done during North-Centre transect. And VMP profiling at the centre location started at 02.09 hrs and completed at 03.16 hrs. Ship then proceeded to the South point. Multiple uCTD profiling was done during South-Centre transect. The second VMP profiling started at 05.00 hrs and continued till 06.09 hrs. This VMP profiling was followed by LADCP at 06.25 hrs. Ship then proceeded to the East point. During East-Centre transect multiple UCTD profiling was done. The third VMP profiling at the centre location started at 08.15 hrs and completed at 09.27 hrs. This VMP profiling was followed by radiometer at 09.33 hrs, CTD and water sample collection at 09.56 hrs, portable CTD profiling at 10.50 hrs and zooplankton net deployment at 11.10 hrs. The fourth VMP profiling at the centre location started at 11.41 hrs and continued till 12.42 hrs. Ship then proceeded to the North point. Multiple uCTD profiling was done during North-Centre transect. The fifth VMP profiling at the centre location started at 14.14 hrs and continued till 15.22 hrs. Ship then proceeded to the South point. During South-Centre

transect multiple uCTD profiling was done. The sixth VMP profiling at the centre location started at 17.27 hrs and continued till 18.19 hrs. This VMP profiling was followed by LADCP operation at 18.30 hrs and zooplankton net deployment at 19.30 hrs. The seventh VMP profiling at the centre location started at 20.17 hrs and continued till 21.31 hrs. Ship then proceeded to the West point. Multiple uCTD profiling was done during West-Centre transect. The final VMP profiling of the day at the centre location started at 23.17 hrs and completed at 00.20 hrs. Ship then proceeded to the North point.

29/09/2019

Multiple uCTD profiling was done during the North-Centre transect. The first VMP profiling of the day at the centre location started at 01.45 hrs and continued till 02.46 hrs. Ship then proceeded to the South point. During South-Centre transect, multiple uCTD profiling was done. The second VMP profiling at the centre location started at 04.53 hrs and completed at 05.54 hrs. This VMP profiling was followed by LADCP operation at 06.02 hrs. Ship then proceeded to the East point. Multiple uCTD profiling was done during East-Centre transect. The third VMP profiling at the centre location started at 08.14 hrs and completed at 09.16 hrs. This VMP profiling was then followed by radiometer operation at 09.22 hrs, CTD and water sample collection at 09.52 and portable CTD profiling at 10.5 hrs. It was then followed by LADCP at 10.57 hrs. The fourth VMP profiling at the centre location started at 12.53 hrs and continued till 13.57 hrs. The fifth VMP profiling at the centre location started at 14.29 hrs and completed at 15.37 hrs. Ship then proceeded to South point. Multiple uCTD profiling was done during South-Centre transect. Zooplankton net deployment was done at 15.40 during the transect while ship was cruising at a speed of 2 knots. The sixth VMP profiling at the centre location started at 17.37 hrs and continued till 18.38 hrs. Which was then followed by LADCP at 18.47 and completed at 19.19 hrs. Ship then proceeded to East point. Multiple uCTD profiling was done during East-Centre transect. The seventh VMP profiling at the centre location started at 20.17 hrs and continued till 21.19 hrs. It was followed by zooplankton net deployment at 21.25 hrs. Ship then proceeded to the West point. During West-Centre transect, multiple uCTD profiling was done. The final VMP profiling at the centre location started at 23.01 hrs and completed at 00.05 hrs next day. Ship then proceeded to the North point.

30/09/2019

Multiple uCTD profiling was done during North-Centre transect. The first VMP profiling of the day at the centre location started at 01.54 hrs and completed at 03.04 hrs. Ship then proceeded to the South point. During South-Centre transect, multiple uCTD profiling was done. The second VMP profiling at the centre location started at 04.51 hrs and Continued till 06.01 hrs. The VMP profiling was then followed by LADCP operation at 06.14 hrs, which was completed at 06.52 hrs. Ship then proceeded to the East point. During East-Centre transect, multiple uCTD profiling was done. The third VMP profiling at the centre location started at 08.13 hrs and continued till 09.03 hrs. The VMP profiling was then followed by radiometer operation at 09.30 hrs, CTD and

water sample collection at 09.54, portable CTD profiling at 10.39 hrs and zooplankton net deployment at 10.59 hrs. The fourth VMP profiling at the centre location started at 11.42 hrs and continued till 12.45 hrs. Ship then proceeded to the North point. Multiple uCTD profiling was done during the North-Centre transect. The fifth VMP profiling at the centre location started at 14.09 hrs and completed at 15.13 hrs. Ship then proceeded to the South point. During South-Centre transect, multiple uCTD profiling was done. During the transect, zooplankton deployment was done at 16.20 hrs while the ship was cruising at the speed of 2 knots. At 16.30 hrs multibeam echo sounder test operation stopped due to power supply problems. The sixth VMP profiling at the centre location started at 17.10 hrs and continued till 18.11 hrs. The VMP profiling was then followed by LADCP operation at 18.25 hrs and zooplankton net deployment at 19.40 hrs. Ship then proceeded to the East point. During East-Centre transect, multiple uCTD profiling was done. The seventh VMP profiling at the centre location started at 20.35 hrs and continued till 21.45 hrs. Ship then proceeded to the West point. Multiple uCTD profiling was done during the West-Centre transect. The final VMP profiling of the day at the centre location started at 23.23 hrs and completed at 00.30 hrs next day. Ship then proceeded to the North point.

01/10/2019

Multiple uCTD profiling was done during the North-Centre transect. The first VMP profiling of the day at the centre location started at 02.02 hrs and completed at 03.05 hrs. Ship then proceeded to the South point. During the South-Centre transect, multiple uCTD profiling was done. The second VMP profiling at the centre location started at 05.02 hrs and continued till 06.06 hrs. The VMP profiling was then followed by LADCP operation at 06.13 hrs and completed at 06.41 hrs. Ship then proceeded to the East point. Multiple uCTD profiling was done during the East-Centre transect. The third VMP profiling at the centre location started at 08.07 hrs and completed at 09.11 hrs. The VMP profiling was then followed by radiometer operation at 09.17 and CTD and water sample collection at 09.40 hrs. The final VMP profiling of the measurements near the mooring started at 11.2 hrs and completed at 12.24 hrs. Boat operation was planned to cut the fishing line which was entangled to the INCOIS flux mooring sensors. Boat operation began at 13.54 hrs and completed at 15.30 hrs. Ship proceeded to the Continental shelf region near Paradip for Internal tide measurements.

02/10/2019

Ship was on transit from the flux mooring site to Paradip during the day. Norinco personals sorted out the power supply issues for the multi beam echo sounder and a trial test of MBES is conducted from 15.00 to 19.00. Multibeam bathymetry survey of the continental shelf region was done from 19.00 hrs 2nd October to 05.00 hrs 3rd October.

03/10/2019

We reached the 1000m depth location (19°59.761N,87°28.159E) and first VMP profiling as part of Internal tide measurements in the continental shelf region begins at 06.17 hrs. The VMP

measurements at the 1000m depth location involved a first profiling with 2 casts and a second profiling at the same location with another 2 casts. The VMP profiling was followed by LADCP deployment at the same 1000m depth location which begins at 09.44 hrs and completed at 11.26 hrs. After this the ship proceeded to the 900m depth location. At the 900m depth location (20°02.256N,87°27.828E) the first VMP profiling with one cast started at 12.02 hrs and completed at 12.34 hrs. Another profiling at the same location with 3 casts started at 13.04 hrs and completed by 14.40 hrs. The VMP profiling was followed by LADCP deployment at the same 900m depth location which began at 15.30 hrs and completed at 17.12 hrs. Ship then proceeded to 700m depth location. The first VMP profiling with one cast at the 700m depth location (20°05.018N,87°27.303E) begins at 17.43 hrs and completed at 18.06 hrs. And another VMP profiling consisted of 3 casts begins at 18.42 hrs and completed at 20.00 hrs. The VMP profiling was followed by LADCP deployment at the same 700m depth location which begins at 20.27 hrs and completed at 21.37 hrs. uCTD measurement transect between 200m depth location (20°09.856N,87°26.264E) and 1000m depth location (19°59.761N,87°28.159E) with multiple profiles begins at 22.45 hrs and completed at 03.45 hrs next day (4th October).

04/10/2019

On this day we did VMP time series at 800m depth location (20°03.884N,87°27.871E). The first VMP profiling consists of 2 casts started at 06.46 hrs and completed at 07.41 hrs. The second VMP profiling consists of 2 casts started at 08.20 hrs and completed at 09.19 hrs. The second VMP profiling is followed by LADCP deployment at the same location which begins at 09.47 hrs and completed at 11.20 hrs. The third VMP profiling consists of 2 casts started at 11.22 hrs and completed at 12.25 hrs. The fourth VMP profiling consists of 2 casts started at 13.13 hrs and completed at 14.14 hrs. The fourth VMP profiling is followed by LADCP deployment which begins at 15.06 hrs and completed by 16.23 hrs. The fifth VMP profiling consists of 2 casts started at 16.39 hrs and completed at 17.42 hrs. The sixth VMP profiling consists of 2 casts started at 18.15 hrs and completed by 19.21. The sixth VMP profiling is followed by LADCP deployment which started at 19.48 hrs and completed by 21.38 hrs. UCTD measurement transect between 200m depth location (20°09.856N,87°26.264E) and 1000m depth location (19°59.761N,87°28.159E) with multiple profiles begins at 23.00 hrs and completed at 04.15 hrs next day (5th October).

05/10/2019

We reached the 600m depth location (20°06.908N,87°27.018E) and first VMP profiling consists of 1 cast started at 06.11 hrs and completed at 07.00 hrs. A second VMP profiling at the same location consists of 3 casts started at 07.30 hrs and completed at 08.13 hrs. The VMP profiling was followed by LADCP deployment at the same 600m depth location which began at 08.54 hrs and completed at 09.56 hrs. After this the ship proceeded to the 500m depth location. At the 500m depth location (20°07.535N,87°26.758E) the first VMP profiling with 2 casts started at 10.15 hrs and completed at 10.56 hrs. Another profiling at the same location with 2 casts started

at 11.22 hrs and completed by 12.01 hrs. The VMP profiling is followed by LADCP deployment at the same 500m depth location which began at 12.40 hrs and completed at 13.30 hrs. Ship then proceeded to 400m depth location. The first VMP profiling with 2 casts at the 400m depth location (20°08.555N,87°26.633E) begins at 14.25 hrs and completed at 14.56 hrs. And another VMP profiling consists of 2 casts begins at 15.29 hrs and completed at 16.01 hrs. The VMP profiling was followed by LADCP deployment at the same 400m depth location which began at 16.30 hrs and completed at 17.06 hrs. The first VMP profiling with 2 casts at the 300m depth location (20°09.299N,87°26.392E) began at 17.31 hrs and completed at 17.57 hrs. And another VMP profiling at the same location consists of 3 casts begins at 18.32 hrs and completed at 19.05 hrs. The VMP profiling was followed by LADCP deployment at the same 300m depth location which began at 19.15hrs and completed at 19.45hrs. uCTD measurement transect between 200m depth location (20°09.856N,87°26.264E) and 1000m depth location (19°59.761N,87°28.159E) with multiple profiles began at 21.00 hrs and completed at 02.00 hrs next day (6th October).

06/10/2019

We reached the 200m depth location (20°09.856N,87°26.264E) and first VMP profiling consists of 2 cast started at 07.27 hrs and completed at 07.43 hrs. A second VMP profiling at the same location consists of 3 casts started at 08.04 hrs and completed at 08.25 hrs. The VMP profiling is followed by LADCP deployment at the same 200m depth location which begins at 09.12 hrs and completed at 09.40 hrs. After this moved along the transect and take measurements at other 8 depth locations starting from 300m depth location (20°09.338N,87°26.406E) to the 1000m depth location (20°00.016N,87°28.131E). At the 300m depth location (20°09.338N,87°26.406E) the VMP profiling with 2 casts started at 10.05 hrs and completed at 10.29 hrs. Ship then proceeded to 400m depth location. The VMP profiling with 3 casts at the 400m depth location (20°08.536N,87°26.592E) began at 10.53 hrs and completed at 11.44 hrs. Ship then proceeded to 500m depth location. The VMP profiling with 2 casts at the 500m depth location (20°07.634N,87°26.710E) began at 12.22 hrs and completed at 13.29 hrs. Ship then proceeded to 600m depth location. The VMP profiling with 2 casts at the 600m depth location (20°06.753N,87°26.850E) began at 14.00 hrs and completed at 14.47 hrs. Ship then proceeded to 700m depth location. The VMP profiling with 2 casts at the 700m depth location (20°05.153N,87°27.204E) began at 16.03 hrs and completed at 17.08 hrs. Ship then proceeded to 800m depth location. The VMP profiling with 2 casts at the 800m depth location (20°03.718N,87°27.509E) began at 17.52 hrs and completed at 18.55 hrs. Ship then proceeded to 900m depth location. The VMP profiling with 2 casts at the 900m depth location (20°02.108N,87°27.802E) began at 19.26 hrs and completed at 20.36 hrs. Ship then proceeded to 1000m depth location. The VMP profiling with 2 casts at the 1000m depth location (20°00.016N,87°28.131E) began at 21.13 hrs and completed at 22.34 hrs. Ship proceeded to Chennai.

07/10/2019

Ship is on way to Chennai and stopped during 5:00 hours and 17:00 hours. VMP, and radiometer measurements were taken followed by zooplankton collection

08/10/2019

Ship is on way to Chennai and stopped during 5:00 hours and 17:00 hours. VMP, and radiometer measurements were taken followed by zooplankton collection. Master and crew gave a farewell party to the science team at 19:30 hours

09/10/2019

Ship is on transit to Chennai Port. Packing of the materials on full swing. A group photo session was done at 16:30 hours. ETA to Chennai port is 08:00 hrs

10/10/2019

Ship reached shallow depth region (~50m) in the morning hours and did a 1 km x 1 km square area bottom tracking for ADCP data correction. Once that was over, ship made port call by 8:00 hours as planned.

Acknowledgements

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Dr. B. Praveen Kumar

Scientist, INCOIS and Chief Scientist SN144