

PRELIMINARY CRUISE REPORT

CRUISE No: SK 351

ORV SAGAR KANYA

3rd August 2018 – 6th September 2018

(Kochi to Goa)

Submitted by

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1. Cruise Summary

Cruise SK351 of ORV *Sagar Kanya* was undertaken under Marine Ecosystem Dynamics of eastern Arabian Sea (MEDAS) project with the aim of understanding the influence of various oceanographic processes on the biogeochemistry and biology of the ecosystem at various trophic levels of eastern Arabian Sea through time series observations. The vessel sailed from Kochi on 3rd August 2018 and reached Goa on 6th September 2018. The sampling of major physical, biogeochemical parameters were carried out along 7 transects (off Cape, Off Kochi, off Mangalore, off Goa, off Mumbai, Off Veraval and off Okha) from different depths (10-2000m). A total of 73 stations were sampled. The 10-20 m station off Cape, 10 m station off Goa, off Mumbai and 10m station off Okha could not be occupied due to navigational problems. Surface waters were collected for taxonomic analysis of phytoplankton. Zooplankton samples were collected using MPN and Bongo nets with concurrent collection of CTD data. The samples were also collected for the measurement of Chlorophyll and accessory Pigments, Phytoplankton absorption (a_{ph}), autotrophic and heterotrophic bacterioplankton, total bacterial and viral abundance, Dissolved Oxygen (DO), Nutrients, Particulate Organic Carbon (POC), Total Organic Carbon (TOC), Dissolved nutrients, Dissolved Inorganic Carbon (DIC), Sediment samples for sediment organic carbon (SOC), and isotopic ratios etc. Sediment samples were also collected for textural analysis and benthic studies. Sampling during the second leg was done at each degree from off okha to goa along the 50m depth contour.

2. Cruise Objectives

- I.** Biogeochemistry of eastern Arabian Sea
- II.** Biological responses including resources to varying ecosystem processes over eastern Arabian Sea.

3. List of scientific participants

Scientific Compliment

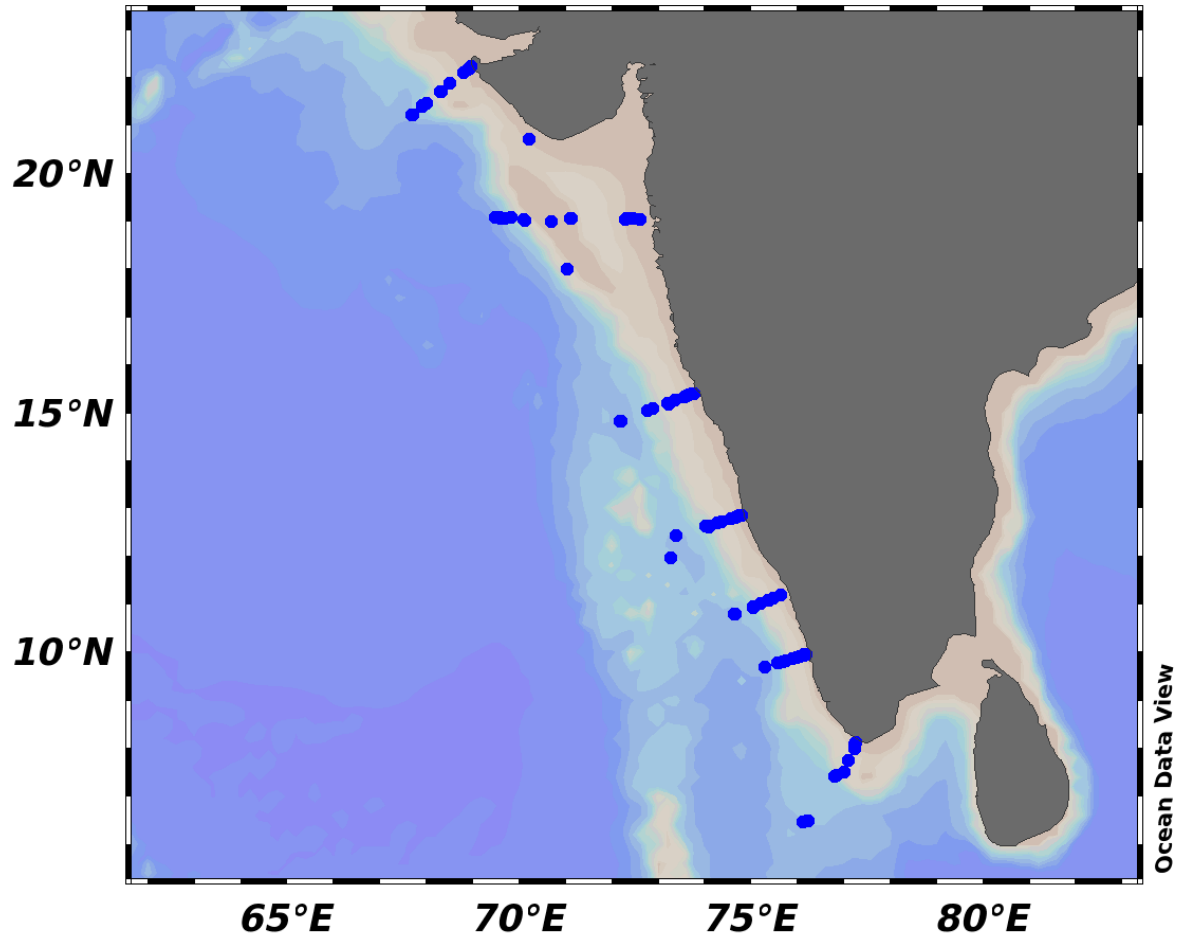
- | | |
|-----------------------------|--------------------------------|
| 1. Dr. Anil Kumar Vijayan | Chief Scientist (CMLRE) |
| 2. Dr.RasheedKunjumohammed | Deputy Chief Scientist (CMLRE) |
| 3. Mrs.Kausar Fatima Bepari | Project Scientist (CMLRE) |
| 4. Mr.SudheeshValliyodan | Project Scientist (CMLRE) |
| 5. Dr.Harikrishnachari.N.V | Project Scientist (CMLRE) |
| 6. Mr.Sherin C.K | Project Scientist (CMLRE) |
| 7. Ms.NaseeraKottangadan | Project Scientist (CMLRE) |
| 8. Dr.SuraAppalanaidu | Project Scientist (NCCR) |
| 9. Dr.V.Damodar Rao | Project Scientist (NCCR) |
| 10. Ms.DikshaDikshit | Project Assistant (CMLRE) |
| 11. Mr. Vishnu Nampoothiri | Project Assistant (CMLRE) |
| 12. Ms.Sarimol.C.N. | Project Assistant (CMLRE) |
| 13. Mr.RahulRaveendran | Project Assistant (NIO, Kochi) |
| 14. Mr.MohammedIqbal.P.M | Project Assistant (NIO, Kochi) |
| 15. Mr.AlbinJose.K | Project Assistant (NIO, Kochi) |
| 16. Ms.RiyaV.Parameswaran | Project Assistant (NIO, Kochi) |
| 17. Ms.Santhi Krishnan | Project Assistant (NIO, Kochi) |
| 18. Mr.Chandrasekhar.K | Project Assistant (NIO, Goa) |
| 19. Ms.Haritha Y.S. | Student, KUFOS |
| 20. Mr.PraveenKumar.K.P | Student, KUFOS |
| 21. Mr.Sanyo Sunny | Student, KUFOS |
| 22. Ms.Swapna Sunil | Student, KUFOS |
| 23. Mr.Shailesh Kumar Yadav | NCAOR, Goa |

Engineering Compliment

- | | |
|----------------------------|---------------------------|
| 24. Mr. P.Boopathy | AMC Service Eng (NORINCO) |
| 25. Mr. R.M.Ismail | AMC Service Eng (NORINCO) |
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4. Details of stations & sampling

Sampling locations



Sampling Details

Stn.no	Date	Time	Lat (N)	Long (E)	Depth (m)	CTD SST (°C)	REMARKS
T2-01	03-08-2018	7:55	9 57.8	76 10.78	13	26.1	Cloudy, Partial raining
T2-02	03-08-2018	9:40	9 57.170	76 8.04	20	27.35	Cloudy
T1-05	04-08-2018	9:30	7 59.5500	77 13.06	50	23.87	Sunny, Calm
T1-04	04-08-2018	15:00	8 5.130	77 13.880	40	23.61	Sunny, White caps, Dark brown water
T1-03	05-08-2018	0.20	8 8.200	77 14.402	30	22.84	
T1-06	05-08-2018	08.00	7 34.38	77 05.32	75	25.82	Sunny water- black uincolour, bongo net clogged in 5 min, high productive area.
T1-07	05-08-2018	20.14	7 30.220	76 59.530	100	27.88	
T1-08	05-08-2018	1.40	7 26.020	76 50.150	500	27.89	Station depth only 248.5
T1-9	05-08-2018	04.00	7 25.330	76 48.020	1111	27.85	
T1-10	07-08-2018	23.00	6 28.970	76 7.950	2000	28.49	
T2-01 Rpt	16-08-2018	18.15	9 57.7500	76 10.9900	17	23.54	16-8-18, 16..00,sailed from Cochin port..On the way water is muddy.Sea is rough. Pouring. At station-heavy pouring heavy wind. Water is turbid. (Flood in Kerala) Sediment-andy, slightly smelly.
T2-02 Rpt	16-08-2018	21.40	9 56.950	76 8.170	17	23.47	Heavy precipitation. Turbid water.
T2-03	17-08-2018	00.00	9 55.4100	76 02.2600	32.2	23.64	Rough
T2-04	17-08-2018	02.50	9, 53.4600	75 58.00	43	23.4	Cloudy, Rough
T2-05	17-08-2018	05.15	9 51.980	75 53.480	53	23.31	Cloudy, Rough
T2-06	09-08-2018	22.30	9 50.00	75 44.40	75	25.74	
T2-07	09-08-2018	18.00	9 48.960	75 40.790	100	26.71	Cloudy, High chl.
T2-08	09-08-2018	17.10	9 47.04	75 15.85	500	27.28	Cloudy, High chl.
T2-09	09-08-2018	12.40	9 47.26	75 34.44	1000	27.55	Pouring, Noctiluca bloom at subsurface. High chl.
T2-10	09-08-2018	04.00	9 42.75	75 19.59	2000	27.81	Noctiluca abundance at subsurface. High chl. Sunny, swells
T3-03	18-08-2018	05.00	11 11.810	75 37.970	34.2	23.05	Choppy with longer waves. Cloudy, Water colour - bluish black
T3-04	18-08-2018	9.15	11 7.690	75 28.390	46	23.39	Sunny upto 10.30 then started raining
T3-05	18-08-2018	13	11 5.010	75 21.570	59	24.02	Cloudy
T3-07	18-08-2018	17.45	11 0.560	75 12.280	101	23.92	Bioluminescence in Bongo Samples.

T3-09	18-08-2018	22.3	10 56.810	75 01.880	965	25.9	CTD winch and cable malfunctioning, rectified.
T3-10	19-08-2018	8.3	10 47.390	76 38.250	2007	27.24	Sunny, windy
Kannur 2000	20-08-2018	14.3	11 58.210	70 15.870	2113	27.35	Sunny, windy
T4-10	20-08-2018	21.3	12 26.050	73 22.920	1982	27.36	Rough, windy
T4-09	21-08-2018	9.05	12 37.63	74 01.5200	1005	25.7	Fluctuating CTD data.
T4-08	21-08-2018	13.3	12 38.100	74 6.080	668	21.12	
T4-07	21-08-2018	16.15	12 42.260	74 15.620	109	26.19	Hydrographic winch malfunction.
T4-06	22-08-2018	0.39					
T4-05	22-08-2018	06.00	12 47.100	74 33.400	50	26	
T4-04	22-08-2018	09.10	12 48.740	74 38.450	40	25.7	Ribbon like patches with floating debris were seen. Bongo samples collected.
T4-03	22-08-2018	12.45	12 50.55	74 42.00	35	26.33	Highly turbid water from subsurface.(must be phytoplankton bloom)
T4-02	22-08-2018	15.45	12 50.920	74 44.310	24	22.48	Upwelling features are seen.
T4-01	22-08-2018	18.00	12 51.1900	74 47.9500	13.5	22.73	Fresh water layer obstructed by the ship. So surface samples from Manglore Port's side collected by Niskin bottle. High sea traffic. Water is muddy. Cloudy.
T6-05	24-08-2018	06.40	15 20.800	73 33.5300	50	25.06	Sea water leaked in the transducer room and flooded. So ADCP and ecosounder are not working. Rolling and pitching correction is also not working. Bongo net torn, stiched.
T6-04	24-08-2018	09.50	15 22.350	73 36.750	40	24.86	Sunny, alm, whitecaps, water colour- blue.
T6-03	24-08-2018	13.05	15 23.80	73 39.63	30	24.91	Sunny, port limit. Clayey sticky samples from grab
T6-02	24-08-2018	15.30	15 24.730	73 43.230	20	22.3	Sunny, port limit.
T6-01	24-08-2018	17.15	15 24.990	73 45.510			Large amount of Debris found
T6-06	24-08-2018	00.00	15 16.200	73 21.280	75	27.29	Calm
T6-07	25-08-2018	03.00	15 12.630	73 11.640	101	27.5	Calm
T6-08	25-08-2018	10.00	15 5.400	72 52.190	500	27.63	Sunny, calm, dark blue water, white caps
T6-09	25-08-2018	13.30	15 3.790	72 45.610	1100	27.66	Blue water, white caps, sunny
T6-10	26-08-2018	01.45	14 50.430	72 10.500	2050	27.36	Calm, first 50 m cast without DP. 2000m
T8-02	27-08-2018	21.45	19 2.9800	72 36.1800	23	27.91	Error in CTD communication cable.

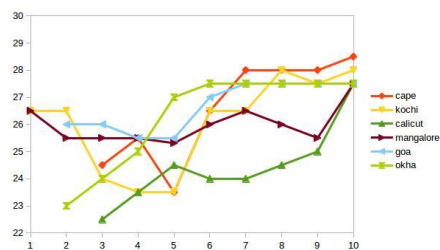
							Rectified.
T8-03	28-08-2018	04.00	19 03.9600	72 27.030	33	27.84	High Chl.
T8-04	28-08-2018	9.55	19 3.900	72 23.070	40.4	27.77	Calm, Dark Green/blue water.
T8-05	28-08-2018	07.00	19 93.5300	72 18.1200	52	27.35	2 water masses seen. Blue and graan water .Boundary between two is clearly visible. This sampli8ng is from the Green water. High productivity.
T8-05front	28-08-2018	08.30	19 03.0900	72 17.2800	53	27.44	Sampling from Blue water.
T8-06	29-08-2018	05.00	19 4.6300	71 6.3900	81.4	27.48	Rough
T8-07	29-08-2018	17.25	19 2.4410	70 6.240	102	27.49	Sunny, 2 niskin bottles broke
T8-08	29-08-2018	23.40	19 4.800	69 49.450	461	27.32	Swells.
T8-09	29-08-2018	01.45	19 04.3100	69 39.4600	1069	27.32	
T8-10	30-08-2018	07.30	19 04.870	60 28.890	2086	27.38	
T10-10	31-08-2018	18.00	21 14.0000	67 41.4800	1938	27.44	Sunny at the start, then clouded and rained.Rough, white caps.
T10-09	01-09-2018	04.00	21 25.27	67 54.940	947	27.38	Rough
T10-08	01-09-2018	08.45	21 28.530	67 59.340	620	27.58	Sunny, Swells, Rough
T10-07	01-09-2018	12.45	21 42.71	68 17.04	105	27.36	Sunny, blue-green water, High traffic
T10-06	01-09-2018	16.45	21 52.990	68 30.360	77	27.49	Sunny, Rough
T10-04	01-09-2018	21.30	22 11.120	68 53.730	41.4	27.58	Cloudy, Calm.
T10-03	01-09-2018	23.35	22 12.490	68 55.660	36	25.22	Cloudy, Calm.
T10-02	02-09-2018	01.00	22 14.560	68 56.860	24.6	23.94	Cloudy, Calm.
T10-05	03-09-2018	04.00	22 6.430	68 47.210	52	27.34	Rough
SK_351_L2_S1	03-09-2018	00.00	20 42.75	70 12.01	51	27.45	Pouring, Rough, Swell
SK_351_L2_S2	03-09-2018	06.30	19 00.55	70 40.66	88	27.49	Calm
SK_351_L2_S3	04-09-2018	05.30	18 00.71	71 01.13	81	27.47	Calm
SK_351_L2_S4	05-09-2018	01.45	16 57.73	73 05.20	52.2	27.75	Calm
SK_351_L2_S5	05-09-2018	09.00	16 15.69	73 10.36	47	26.61	Sunny
SK_351_L2_S6	05-09-2018	07.45	15 20.630	73 33.590	51	26.91	Calm

5. Brief report of the work done onboard

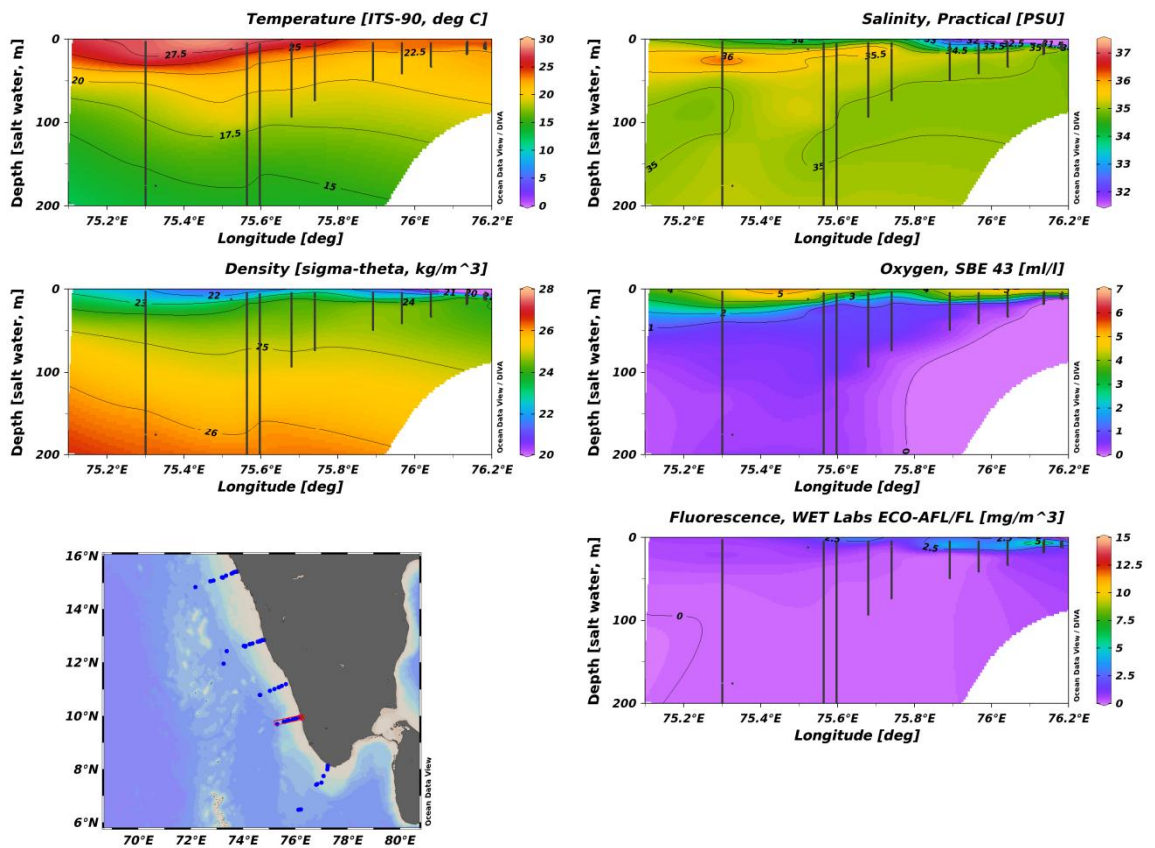
5.1. Physical Oceanography:

The CTD was operated at all stations for the collection of hydrographic parameters like temperature, salinity, PAR, density, fluorescence etc. The SST was measured using bucket thermometer. Mixed layer depth, Isothermal layer depth, D15 (depth showing 15 °C temp) and D26 (depth showing 26 °C temp) isotherm was calculated from the CTD profiles. Wind speed, Wind direction, Air temperature, Relative Humidity, Pressure Long Wave Radiation, Short wave Radiation was acquired from AWS and monitored for all stations.

SST



Vertical distribution of various physico-chemical parameters along Kochi transect.



XBT and XCTD Deployment:-

Used XBT probe for measuring the vertical profile of temperature from surface up to 760m meters. For measuring conductivity, temperature, density, salinity and sound velocity with depth using XCTD probe. In this cruise, deployed T-7 type probe for XBT for measuring the temperature profile upto 760m at a maximum speed of 15 knots and XCTD-1 type probe for XCTD which can go up to a maximum depth of 1000m with a maximum speed of 12 knots.



Probe Type	Max Depth (m)	Max Speed (kt)
XBT		
<input type="checkbox"/> LMS Probe		
<input type="radio"/> T-4	460	30.0
<input type="radio"/> T-5	1830	6.0
<input type="radio"/> T-6	460	15.0
<input type="radio"/> T-7	760	15.0
<input type="radio"/> TDB (8)	760	20.0
<input type="radio"/> T-10	300	10.0
XCTD		
<input checked="" type="radio"/> XCTD1	1000	12.0
<input type="radio"/> XCTD2	1850	3.5
<input type="radio"/> XCTD3	1000	20.0
<input type="radio"/> XCTD4	1850	6.0



A total of 20 XBTø and 8 XCTDø in all transects. The XBTø were used at 750m, 1250m, and 1500m depths and XCTD at 2000m depth (at the time of deploying CTD). At Kochi 750m and Okha 750m Stationø XBTø are failed due to heavy wind action. XCTD deployed at Cape 2000m recorded data up to 700m while Kochi 2000m XCTD recorded up to 480m. Due to data communication problem Calicut and Mangalore XCTDø operations failed.

Table.1 Details of XBT deployment at different locations

S. No.	Lat. (° N/S)	Long. (° E)	Date	Time (LST)	Transect name	Ship Speed (knots)	Depth (m)
1	07 26 N	76 48 E	06-08-2018	03:27	Cape	6	750
2	07 22 N	76 45 E	06-08-2016	10:00	Cape	5.8	1500
3	09 44 N	75 25 E	09-08-2018	11:33	Kochi	7	1500
4	09 46 N	75 30 E	09-08-2018	12:14	Kochi	7	1250
5	09 47 N	75 34 E	09-08-2018	16:56	Kochi(failed)	2	750
6	10 57 N	75 04 E	18-08-2018	22:18	Calicut	5	750
7	10 55 N	74 59 E	19-08-2018	05:08	Calicut	6.2	1250
8	10 53 N	74 54 E	19-08-2019	05:58	Calicut	6	1500
9	12 34 N	73 50 E	21-08-2018	07:09	Mangalore	5.5	1500
10	12 36 N	73 57 E	21-08-2018	08:17	Mangalore	5	1250
11	12 37 N	74 05 E	21-08-2018	13:31	Mangalore	4.4	750
12	15 04 N	72 49 E	25-08-2018	12:35	Goa	5.2	750
13	14 59 N	72 35 E	25 -08-2018	19:35	Goa	6	1250
14	14 56 N	72 27 E	25-08-2018	21:10	Goa	5.8	1500
15	19 03 N	69 44 E	30-08-2018	01:02	Mumbai	5.5	750
16	19 03 N	69 37 E	30-08-2018	05:42	Mumbai	4.5	1250
17	19 04 N	69 32 E	30-08-2018	06:46	Mumbai	4.3	1500
18	21 23 N	67 52 E	01-09-2018	04:07	Okha	6.8	1500
19	21 23 N	67 53 E	01-09-2018	04:19	Okha	4	1250
20	21 26 N	67 57 E	01-09-2018	08:00	Okha(failed)	1.5	750

S.no.	Lat. (° N/S)	Lon. (° E)	Date	Time	Transect	Ship Speed (knots)	Depth(m)
1	07 28 N	76 06 E	07-08-2018	00:35	Cape	0	2000
2	09 41 N	75 18 E	09-08-2018	07:01:26	Kochi	0	2000
3	10 47 N	74 38 E	19-08-2018	13:45:00	Calicut(failed)	0	2015
4	12 26 N	12 26 E	20-08-2018	23:10:00	Mangalore(failed)	0	2000

5	12 26 N	73 22 E	20-08-2018	23:41:00	Mangalore	0	2000
6	14 49 N	72 10 E	26-08-2018	03:29:41	Goa	0	2050
7	19 04 N	69 27 E	30-08-2018	08:20:54	Mumbai	0	2000
8	21 13 N	67 41 E	31-08-2018	19:37:22	Okha	0	2000

Table.2 Details of XCT operations at different locations

5.2. Chemical oceanography: The parameters studied include DO, pH, Nutrients, Urea, Total nitrogen, Total phosphorus, carbon parameters (POC, TOC, and DIC).

For the determination of dissolved oxygen water sample was collected from the Rosette immediately upon its arrival on deck. The samples were collected in 125 ml borosilicate glass bottles with a ground glass stopper. Extreme care was taken to avoid bubble formation during the sampling. After collection of samples the DO was fixed with 1ml of Winkler A and B and the samples were analyzed by potentiometric method (Carpenter, 1965).

For the determination of pH the sea water sample was collected directly from the Niskin bottle using the drawing tube into the 10 cm spectrophotometric cell. After several flushing with seawater the cell was sealed with the PTFE caps ensuring that there is no head-space. The pH of the sample measured immediately by spectrophotometer using Cresol red indicator at wavelengths 730, 578 and 434 nm respectively. About 1 -2 L of water samples were filtered through pre-combusted GF/F filter (0.7 μ m pore size; 47mm diameter; Whatman) at 450°C for 4 h, at low vacuum and the filters were stored at -20°C for POC analysis. The filtrate was collected in 22 ml screw cap glass vials and preserved with H₃PO₄ for DOC analysis. The samples collected for dissolved nutrient and TN/TP (except ammonia) were filtered through GF/F filter paper for removing the particulate matter and the filtrate collected in 100 and 60 ml HDPE bottles and poisoned with saturated HgCl₂ until the analysis. Samples were collected separately in 40ml Nalgene bottles and frozen at -20 °C for the analysis of ammonia.

The sediment samples after collection were dried at 60°C for overnight and grained and the powdered samples were sieved with 100 μ m sieve, packed in 10 ml vials for further SOC and isotopic analysis. Sediments are also collected for particle size and

metal analysis. Sediment samples for pigments analysis were stored at -20°C after immediate collection. After sieving (pre-processing macro benthos) samples were fixed with 10% formalin and stored in 500ml plastic bottles. All the samples after pre-processing were stored at the required temperatures to be taken to the shore laboratory for further analysis.

5.3. Biological oceanography: The parameters studied include phytoplankton and zooplankton biomass, chlorophyll and accessory pigment, sediment pigments, autotrophic and heterotrophic bacterioplankton, total bacterial and viral abundance, macro & meio benthos, also sediment samples for texture and isotopic studies.

Water samples for estimation of taxonomy fluorescence and absorption: Surface water samples were collected from all stations for the microscopic analysis of phytoplankton. The water samples from standard depths (10, 20, 30, 40, 50, 75, 100, 200, 500, 1000, 2000 m) were collected from Niskin bottles operated at various depths in each station and filtered by gentle vacuum filtration under low light conditions. For filtration, a minimum of 2 L were taken for absorption analysis of phytoplankton (a_{ph}) and detritus (a_{dg}), and 2L for chlorophyll and accessory pigment analysis using HPLC base method. Size fractionation filtration were done by using three different filters of mesh size $20\mu\text{m}$, $2\mu\text{m}$ and $0.2\mu\text{m}$ for micro, nano and pico-plankton respectively. Samples were grouped by station, completely labeled and wrapped in aluminum foil during storage and kept in frozen condition in liquid nitrogen.

Chlorophyll *a*

The water samples were collected using Niskin bottles (12L), for total and size fractionated chlorophyll *a* (*chl_a*) analysis. The water samples were kept in black plastic cans and 2000 ml of water samples were analysed for all locations. The total *chl_a* filtered with $0.22\mu\text{m}$, and for size-fractionated *chl_a* were consecutively filtered (2000ml) through $200\mu\text{m}$ nylon membrane (Meso size), $20\mu\text{m}$ (micro size), $3\mu\text{m}$ (nano size) and $0.22\mu\text{m}$ (pico size) pore polycarbonate filter papers (Millipore).

Bacterioplankton

To estimate the autotrophic and heterotrophic Bacterioplankton (nanoplankton and picoplankton) 10ml of water samples were collected from all the proposed depths in the photic zone. The samples were fixed with glutaraldehyde and kept in -20°C for further analysis.

Microzooplankton

For microzooplankton, five litre sample were collected and removed the particles size between <20 and >200 µm with pre-filtered primarily with 200 µm bolting mesh and then 20 µm sieve and stored in black polythene bottles and preserved in acid 3% acid Lugol's iodine solution. The samples were concentrated into 200ml using the gravity settling method for further analysis.

Mesozooplankton

Mesozooplankton (MSP) samples were collected from all the proposed stations (50 Nos.) using either bongo or Multiple Plankton Net (MPN) or both (mesh size 200 µm). Surface MSP was collected from all the locations using the bongo net, whereas the MPN was not operated in 10, 20, 75 and 500m depth stations. Bongo net was horizontally towed for ten minutes in all the locations. The speed of the vessel was adjusted to ~ 2 knots. The depth strata for MPN operation was predefined as surface to Mixed Layer Depth (MLD), MLD- bottom of Thermocline and Oxygen Minimum Zone (OMZ). The actual depths were decided over CTD observations on board and materialized wherever possible. After the removal of large particles, the biomass of the zooplankton were analysed using the standard displacement volume (DV) method and the samples were preserved in 4% formaldehyde for later enumeration and identification.

Microbiology Analysis

Water samples were collected from various depths in the five transects. The total plate count was performed on Zobell marine agar plates. For total bacterial and viral abundance (TC) analysis, samples were fixed with formalin and filtered through anodisc membrane. Similarly, for total viable count (TVC) samples were stained with acridine orange and filtered through black nucleopore filter. The abundance will be counted using epifluorescence microscope at laboratory. Water samples were

filtered for DNA isolation for metagenome analysis. Further analysis has to be carried out in laboratory.

6. Suggestions and recommendations

- a) A deep freezer (-80°C) should be provided onboard.
- b) The working condition of all equipmentø should be ensured and should be certified by Chief Scientist at the end of the cruise.
- c) Leakage of CTD Niskin bottles may be rectified and additional 5 L bottles may be made available.
- d) Oil leakage in the main deck may be checked and safety chain may be installed during CTD operations
- e) Dim lights at almost all labs especially chemical and multipurpose labs may be replaced.

7. Acknowledgements

The whole hearted support and co-operation extended by the Master, officers and crew of ORV *Sagar Kanya* to the scientific team is acknowledged with gratitude. We wish to express our deep sense of gratitude to the Director, NCAOR for allotting the ship time for us.

Anil Kumar Vijayan
Chief Scientist SK-351