INDIA

# Cruise Report

## ORV Sagar Kanya

## Cruise # 338

**From: Chennai, 28th January, 2017**

**To: Goa, 3rd March, 2017**

**Chief Scientist: Mr. Venkatesh Chinni**

**Geosciences Division,**

**Physical research Laboratory, Ahmedabad**

## Itinerary of the SK-338 cruise program

| | |
|---|---|
| **Name of vessel** | **ORV Sagar Kanya** |
| **Cruise No.** | **338** |
| **Port of embarkation** | **Chennai, India** |
| **Date of embarkation** | **27 January, 2017** |
| **Port of disembarkation** | **Goa, India** |
| **Date of disembarkation** | **4 March, 2017** |
| **No. of scientist participated** | **21** |
| **Region** | **Bay of Bengal, Arabian Sea, Andaman Sea and Indian Ocean** |
| **Operations** | **Clean CTD, McLANE, IDRONAUT CTD, Peterson Grab, Gravity coring** |
| **Sample type** | **Seawater, and sediment** |
| **Parameters studied** | **Trace Elements and their Isotopes, Particulate matter, C-14, DO, pH, Alkalinity, Neodymium and Hafnium isotopes, Nitrate, Nitrite, Phosphate, Silicate, Ammonia, DOC, DIC, POC, HPLC pigments, Primary Productivity, Aerosol composition and chemical characterisation.** |
| **Name of the Chief Scientist** | **Mr. Venkatesh Chinni** |

## Participating Institutes:

1) Physical Research Laboratory (PRL), Ahmedabad

2) National Institute of Oceanography (NIO), Regional Centre, Vishakhapatnam

3) Mangalore University, Mangalore

4) National Centre for Antarctica & Ocean Research (NCAOR), Goa

# Sagar Kanya

**Cruise Report**

**Cruise No. 338**

## GEOTRACES Programme

### Introduction

Trace elements and their isotopes (TEIs) can function as micro-nutrients, contaminants, and tracers or proxies of various oceanographic processes. Results from the Geochemical Ocean Sections Study (GEOSECS) of the 1970s led too much of this recognition; however, only a few TEIs were determined during the early programs. The development of clean sampling protocols and new, highly sensitive analytical methods, combined with advances in modelling tools that can link and synthesize large data sets, have revolutionized our ability to study the marine biogeochemical cycling of trace elements and isotopes on global scale.

### Indian Ocean

The Indian Ocean is the only ocean that is bounded by land at the tropical latitudes around 26°N. The northern Indian Ocean comprises of two major basins, the Arabian Sea in the northwest and the Bay of Bengal in the northeast. These basins experience very different hydrographic and climatic conditions. The Arabian Sea is a region, where evaporation exceeds precipitation and runoff while the reverse holds true for the Bay of Bengal. Moreover, the southwest Monsoon winds are also stronger over the Arabian Sea, forcing upwelling along both the western (off Oman, Yemen and Somalia) and eastern (off India) boundaries. The monsoon circulation is predominately wind-driven, although in some locations it is modified by heat and fresh-water fluxes. Both the Arabian Sea and the Bay of Bengal experience severe oxygen depletion at mid-depths.

Arabian Sea is a region experiencing seasonally reversing monsoon which affects circulation and biological productivity causing subsurface oxygen deficient conditions. Dueto strong winds associated with southwest monsoon, several areas of the Arabian Sea experience upwelling which leads to surfacing of the nutrient rich waters to the euphotic zone and thereby leading to enhance productivity. This high primary productivity is one ofthe major factors responsible for prevalence of suboxic conditions in the Arabian Sea. Denitrification process which is a perennial feature of the water column of the Arabian Sea is expected to have control on the distribution of redox sensitive elements. Therefore, we planned to measure various trace elements and their isotopes to understand their biogeochemical behaviour and the processes governing their distribution.

Atmospheric deposition is one of the most dominant and effective means of delivering trace element and their isotopes (TEIs) to surface waters of interest to GEOTRACES. This is particularly the case in the Indian Ocean, where enclosed sub-basinsto the north are located in close proximity to large arid areas of dust and large human populations with related industrial emissions located on the Indo-Asian sub-continent. This includes the Arabian Sea, which is impacted by dust and other aerosol emissions from both the Indian subcontinent to the west and East Asian regions to the east. The mineral aerosol is particularly prevalent during the inter-monsoon winter period.

**Objectives**

The present GEOTRACES Section Cruise is an attempt to understand various biogeochemical processes controlling the distributions of various trace elements and their isotopes (TEIs) along the section GI-10 that comprises of Bay of Bengal, Andaman Sea and Arabian Sea. The objectives of this study can be classified under the following themes:

**Sources, sinks and internal cycling**

1) To understand and quantify how the water masses are modified after the contact with the margins and the river mouths within the energetic continent/ocean interface surrounding the Bay of Bengal, Andaman Sea, Arabian Sea and in the Indian Ocean basin.

2) To understand the role of TEIs in primary productivity and their distribution within the water column.

3) Atmospheric deposition of TEIs, their fluxes and processes.

4) To calibrate the behaviour of paleo-circulation and paleo-weathering proxies

5) To understand the various physical processes governing ocean circulation, productivity being controlled by micronutrients, ecosystem and ocean anoxia.

This cruise is an attempt to address some of these issues in context of the Indian Ocean and would try to cover the GEOTRACES Section Cruise - 10 as decided by the working group during the GEOTRACES Indian Ocean meeting.

**Material and methods**

This cruise was allocated to GEOTRACES for studies of water and sediments for the GEOTRACES Section – 10 for measurement of several trace elements and their isotopes (TEIs) to understand various biogeochemical processes responsible for their distribution in the Indian Ocean region. One of the major requirements for the GEOTRACES cruise was requirement of clean sampling system which was procured for this programme and the clean sampling system was successfully operated during the cruise for seawater sampling.

**a) Trace metal clean sampling systems**

Rapid and non-contaminating sampling system for trace elements with a complete facility for trace-metal clean seawater sampling at sea (e.g., non-contaminating rosettewith GO-Flo or

NISKIN bottles; non-contaminating Kevlar wire; clean lab with HEPA filtered air for processing samples) was acquired for the first time in the Indian Ocean region for the GEOTRACES India project by Physical Research Laboratory, Ahmedabad with generous support of Ministry of Earth Sciences, New Delhi (MoES). This trace metal clean sampling system is a valuable asset to GEOTRACES.

**b) Sediment sampling**:

For paleoclimatic studies, long cores from various areas were collected with gravity corer.

**c) Grab sampling**:

For surface sediment, grab sampling was operated at various locations.

Additionally, various scientific equipments were used for onboard analysis are as follow:

1) CTD with rosette with 10 L Niskin sampler

2) Autosal for salinity measurements

3) Thermosalinograph

4) Water purification system (Milli-Q)

5) Deep freezers

6) Ovens

7) Refrigerators

8) Multibeam sounder

9) Laminar flow bench

10) Fume hoods

11) Deep sea Echo-sounder

13) UV Oxidation unit

14) SKALAR Auto Analyzer

**Sampling details**

The scientific operations carried out at the stations across a range of contrasting regions in the Bay of Bengal, Andaman Sea, Arabian Sea and the Indian Ocean during the cruise SK- 338 are described below:

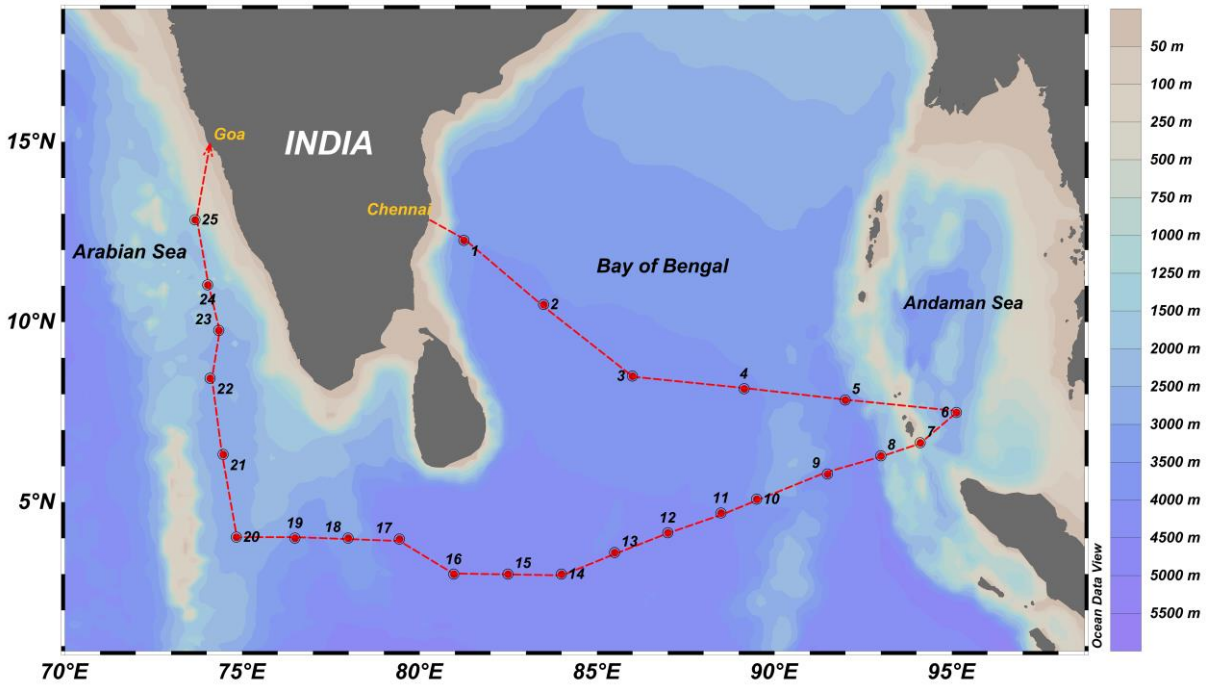



**Figure: Cruise track for SK – 338**

# Daily Report

## SK 338/01

## 29.01.2017 10:00

Lat: 12° 15.987´ N; Long: 81° 15.049´ E; total water column depth 3417m (MBES)

**Clean CTD Cast 1**

3200 m, 2800 m, 2400 m, 2000 m, 1500 m

**Clean CTD Cast 2**

200 m, 150 m, 100 m, 75 m, 50 m, 25m

**Clean CTD Cast 3**

200 m, 150 m, 50 m, 25m, 15m, 10m, 5m, 0m

**Clean CTD Cast 4**

1200 m, 1000 m, 800 m, 600 m, 300m

**Clean CTD Cast 5**

200 m, 100 m, 75 m, 50 m, 25m, 10 m, 2 m

McLANE water pumping system started lowering at 0130 hrs to 2000 m.

Pump started working after reaching 2000 m per the predefined time. Started heaving at 0530 hrs. Unfortunately, we lost McLANE pump at 0600 hrs along with the deep-sea winch wire of length around 1500 m.

Started moving to next station at 0630 hrs on 30/01/2017.

## SK 338/02

## 31.01.2017 1035 hrs

Lat: 10° 29´ N; Long: 83°29.99´ E; Total water column depth 3566 m

**Clean CTD Cast 01**

3200, 2800, 2400, 2000, 1800, 1500, 1200, 1000, 800, 500, 300, 200, 150,100, 75, 50, 30, 20, 10, 2 m.

**IDRONAUT CTD Cast 1**

200 m, 150 m, 15 m. Bottles didn't close.

Identified the problem and rectified.

**IDRONAUT CTD Cast 2**

Collected sample at 0 m.

**IDRONAUT CTD Cast 3**

Collected sample at 100 m.

**IDRONAUT CTD Cast 4**

Collected sample at 5 m.

**Clean CTD Cast 02**

200 m, 150 m, 75 m, 50 m, 25 m,

Started moving to next location at 1730 hrs.

## SK 338/03

## 01.02.2017 2015 hrs

Lat: 08° 30.004´ N; Long: 86° E; total water column depth 3669 m

**Clean CTD Cast 1**

Sampled at 3400m, 3000m, 2500m, 2000m, 1800m,1500m

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m

**IDRONAUT CTD Cast 4**

Collected sample at 15 m

**IDRONAUT CTD Cast 5**

Collected sample at 25 m

**IDRONAUT CTD Cast 6**

Collected sample at 50 m

**IDRONAUT CTD Cast 7**

Collected sample at 75 m

**IDRONAUT CTD Cast 8**

Collected sample at 100 m

**IDRONAUT CTD Cast 9**

Collected sample at 150 m

**IDRONAUT CTD Cast 10**

Collected sample at 200 m

**Clean CTD Cast 2**

Collected samples at 1500m, 1200m, 1000 m, 800m, 500m

**Clean CTD Cast 3**

Collected samples at 300m, 200m,150m, 100m, 75m, 50m, 25m, 15m, 5m

**Clean CTD Cast 4**

Collected samples at 100m, 15m

**Gravity corer**

Started lowering gravity corer at 800 hrs on 02/02/2017. No sediment collected in the gravity core.

**McLANE**

Lowered McLANE water pumping system upto 100 m to collect particulate matter. Found 185 L of seawater passed through the filter in 2 hours. Collected 33µ, 0.8 µ, 0.45µ filters at this depth.

All operations over and moved to next location at 1625 hrs (02/02/2017).

## SK 338/04

## 03.02.2017 23:30

Lat: 08° 08.884´ N; Long: 89° 08.912´ E; Total water column depth 3577m

**Clean CTD Cast 1**

Clean CTD lowered upto 3300m

Sampled at 3350m, 3100m, 2800m,2500m, 2000m, 1800m, 1500m, 1200m, 1000m, 800m, 500m, 300m

Clean CTD on deck at 0210 hrs

**Clean CTD Cast 2**

Clean CTD lowered upto 1000 m

Sampled at 1000m, 200 m, 150m , 100m ,70m, 60m, 50m, 20m, 10m, 0m

CTD on deck at 0545 hrs

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m

**IDRONAUT CTD Cast 4**

Collected sample at 15 m

**IDRONAUT CTD Cast 5**

Collected sample at 25 m

**IDRONAUT CTD Cast 6**

Collected sample at 50 m

**IDRONAUT CTD Cast 7**

Collected sample at 75 m

**IDRONAUT CTD Cast 8**

Collected sample at 100 m

**IDRONAUT CTD Cast 9**

Collected sample at 150 m

**IDRONAUT CTD Cast 10**

Collected sample at 200 m

**Gravity coring**

Lowered corer at 0600 hrs.

Corer on deck at 0815 hrs and retrieved a 2.3 m long sediment core.

All operations are over and moved to next location at 0845 hrs.

## SK 338/05

## 05.02.2017 1100 hrs

Lat: 07°50.018´ N; Long: 91° 59.87´ E; total water column depth 3435.70 m

**Clean CTD Cast 1**

Clean CTD lowered upto 3300 m at 1130 hrs

Clean CTD on deck at 1350 hrs

Sampled at 3300m, 3000m, 2500m, 2000m, 1800m, 1500m, 1200m, 1000m,

800m, 500m, 300m, 200m

CTD data has not recorded. So, decided to lower clean CTD again to a depth of 3300 m for basic parameters information.

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m

**IDRONAUT CTD Cast 4**

Collected sample at 15 m

**IDRONAUT CTD Cast 5**

Collected sample at 25 m

**IDRONAUT CTD Cast 6**

Collected sample at 50 m

**IDRONAUT CTD Cast 7**

Collected sample at 75 m

**IDRONAUT CTD Cast 8**

Collected sample at 100 m

**IDRONAUT CTD Cast 9**

Collected sample at 150 m

**IDRONAUT CTD Cast 10**

Collected sample at 200 m

**Clean CTD Cast 2**

Started lowering clean CTD to a depth of 3300 m and collected samples at 3000 m, 1000 m, 200 m, 150 m, 100 m, 75 m, 50 m, 25 m, 15 m, 05 m

CTD on deck at 1810 hrs

**Clean CTD Cast 3**

Started lowering CTD to a depth of 200 m and collected samples for 200 m, 150 m, 100 m, 75 m, 50 m, 25 m, 15 m, 5 m

CTD on deck at 1920 hrs.

**McLANE**

Planned to operate McLANE at 100 m, 500 m, 1000 m

Integration time set is 2 hours

Sample volume to be pumped 800 L per 2 hours.

McLANE started lowering at 2023 hrs. McLANE reached 100 m at 2030hrs.

Pump started according to the pre defined time 2045 hrs.

McLANE started heaving at 2250 hrs.

McLANE on deck at 2305 hrs.

Filters collected were 33 micron, 0.8 micron and 0.45 micron. A total of 596 L of seawater were pumped through the filter.

Started lowering McLANE to a depth of 500 m at 2325 hrs.

Started heaving at 0150 hrs. Data log file shows only 3.15 L pumped as the minimum flow rate of 7L/min was reached which stopped the pump. So, no sample at 500 m depth at this location.

Now, reduced minimum flow rate from 7 L/min to 6 L/min and deployed McLANE to a depth of 1000 m at 0240 hrs.

Pump started at 0315 hrs and stopped pumping at 0515 hrs. Started heaving McLANE and it is on deck at 0555 hrs.

A total of 683 L of seawater was pumped through filters and collected 33 , 0.8, 0.45 micron filters.

**PETERSON GRAB**

Multibeam survey shows that bottom surface is not a flat area and it is a ridge. So, decided to operate grab. Started lowering grab at 0600 hrs.

Grab didn't close and got nothing.

All operations at this location is over and started moving to next location at 0900 hrs (06/02/2017).

## SK 338/06

## 07.02.2017 1600 hrs

Lat: 7° 29.381´ N; Long:95°07.895´ E; total water column depth 2579.5 m

**Clean CTD Cast 1**

1620 hrs Clean CTD lowered up to 2400 m

1915 Clean CTD on deck

Sampled at 2400 m, 2000 m, 1800 m, 1500 m, 1200 m, 1000 m

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m

**IDRONAUT CTD Cast 4**

Collected sample at 15 m

**Clean CTD Cast 2**

2100 hrs Clean CTD lowered up to 1000 m

2205 Clean CTD on deck

Sampled at 1000 m, 800 m, 600 m, 300 m, 200 m, 150 m

Due to strong current and wind, unable to lower Clean CTD

**Gravity Core**

2330 gravity core down

0130 gravity core up and 4 m core recovered

**IDRONAUT CTD Cast 5**

Collected sample at 25 m

**IDRONAUT CTD Cast 6**

Collected sample at 50 m

**IDRONAUT CTD Cast 7**

Collected sample at 75 m

**Clean CTD Cast 3**

0220 hrs Clean CTD lowered up to 10 m

0230 hrs Clean CTD on deck

Sampled at 10 m

**Clean CTD Cast 4**

0245 hrs Clean CTD lowered up to 200m

0330 Clean CTD on deck

200m, 150m, 100m, 75m, 50m, 25m,10m, 2m

0330 Clean CTD on deck

Operations over and started moving to next location at 0345 hrs (08/02/2017).

## SK 338/07

## 08.02.2017 1330 hrs

Lat: 6° 38.915´ N; Long: 94°06.798´ E; total water column depth 2007 m

Ship is unable to hold in DP mode due to strong wind. Started lowering to 1800 m. While lowering CTD load again started increasing on DP. On Captains call, we aborted lowering further (below 1000 m) and collected samples up to 1000 m only.

**Clean CTD Cast 1**

Clean CTD lowered up to 1000 m

Sampled at 1000m, 800m, 500m,300m, 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

Started IDRONAUT sampling at 1710 hrs.

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m and 10m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m and 15m

**IDRONAUT CTD Cast 4**

Collected sample at 15 m and 25m

**IDRONAUT CTD Cast 5**

Collected sample at 25 m and 50 m

**IDRONAUT CTD Cast 6**

Collected sample at 75 m

**IDRONAUT CTD Cast 7**

Collected sample at 100 m

Completed IDRONAUT CTD sampling at 2025 hrs

**Gravity Core**

2030 gravity core down

2215 gravity core up and 1.5m core recovered

## SK 338/08

## 09.02.2017 0600 hrs

Lat: 06°16.997´ N; Long: 92° 59.98´ E; Total water column depth 1787.4m

**Clean CTD Cast 1**

0700 hrs Clean CTD lowered up to 1600 m

1600m, 1400m, 1200m, 1000m, 800m, 600m, 300m, 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

Clean CTD on deck at 0800 hrs

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m and 15m

**IDRONAUT CTD Cast 4**

Collected sample at 25m

**IDRONAUT CTD Cast 5**

Collected sample at 50 m

**IDRONAUT CTD Cast 6**

Collected sample at 75 m

**IDRONAUT CTD Cast 7**

Collected sample at 100 m

Completed IDRONAUT CTD sampling at 2025 hrs

## SK 338/09

## 09.02.2017 2330 hrs

Lat: 05° 46.9126´ N; Long: 091° 29.795´ E; Total water column depth 3812m

**Clean CTD Cast 1**

0030 hrs Clean CTD lowered up to 3600m

08:05 Clean CTD up on board

Sampled at 3600m, 3300m, 3000m, 2500m, 2000m, 1800m, 1500m, 1200m, 1000m, 800m, 500m, 300m

Clean CTD on deck at 0200 hrs.

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m and 15m

**IDRONAUT CTD Cast 4**

Collected sample at 25m

**IDRONAUT CTD Cast 5**

Collected sample at 50 m

**IDRONAUT CTD Cast 6**

Collected sample at 75 m

**IDRONAUT CTD Cast 7**

Collected sample at 100 m

**Clean CTD Cast 2**

Clean CTD lowered up to 200m

Sampled for 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

0530 hrs Clean CTD on deck

**Gravity Core**

0545 gravity core down

1000 hrs gravity core up and 2.7 m core recovered

Operations over and started moving to next location at 1015 hrs.

## SK 338/10

## 11.02.2017 0500 hrs

Lat: 05° 05.017´ N; Long: 089°29.959´ E; total water column depth 3380.6 m

**Clean CTD Cast 1**

0540 Clean CTD lowered up to 3200 m

0830 hrs Clean CTD on deck

Sampled at 3200m, 3000m, 2500m, 2000m, 1800m, 1500m, 1200m, 1000m,

**Clean CTD Cast 2**

1100 hrs Clean CTD lowered up to 2500m

Sampled at 2500m, 800m, 600m, 300m, 200m, 100m

CTD on deck at 1300 hrs

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m and 15m

**IDRONAUT CTD Cast 4**

Collected sample at 25m

**IDRONAUT CTD Cast 5**

Collected sample at 50 m

**IDRONAUT CTD Cast 6**

Collected sample at 75 m

**IDRONAUT CTD Cast 7**

Collected sample at 100 m

**Clean CTD Cast 3**

1440 Clean CTD lowered up to 3200 m

1540 hrs Clean CTD on deck

Sampled at 300m, 100m, 75m, 50m, 25m, 10m, 5m

**Clean CTD Cast 4**

1630 Clean CTD lowered up to 3200 m

1650 hrs Clean CTD on deck

Sampled for 10m

**McLANE**

Planned to operate McLANE at 100 m, 500 m, 1000 m

Integration time set is 2 hours. Flow rate 6L/minute

Sample volume to be pumped 800 L per 2 hours.

McLANE started lowering at 1715 hrs. McLANE reached 100 m at 1730hrs.

Pump started according to the pre defined time 1730 hrs.

McLANE started heaving at 1935 hrs.

McLANE on deck at 1945 hrs.

Filters collected were 33 micron, 0.8 micron and 0.45 micron. A total of 703.62 L of seawater were pumped through the filter.

Started lowering McLANE to a depth of 500 m at 2000 hrs.

Pump started according to the pre defined time 2030 hrs.

McLANE started heaving at 2235 hrs.

McLANE on deck at 2250 hrs.

A total of 678 L of seawater was pumped through filters and collected 33 , 0.8, 0.45 micron filters.

Started lowering McLANE to a depth of 1000 m at 2250 hrs.

Pump started according to the pre defined time 2330 hrs.

McLANE started heaving at 0135 hrs.

McLANE on deck at 0155 hrs.

A total of 684 L of seawater was pumped through filters and collected 33, 0.8, 0.45 micron filters.

All operations over and started moving to next location at 0205 hrs.

## SK 338/11

## 12.02.2017 1310 hrs

Lat: 04°41.981´ N; Long: 88° 30.02´ E; total water column depth 4005 m

**Clean CTD Cast 1**

1330 hrs Clean CTD lowered up to 3800 m

1540 hrs Clean CTD on deck

Sampled at 3800m, 3500m, 3000m, 2500m, 2000m, 1800m, 1500m, 1200m,

1000m, 800m, 500m, 300m

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m and 15m

**IDRONAUT CTD Cast 4**

Collected sample at 25m

**IDRONAUT CTD Cast 5**

Collected sample at 50 m

**IDRONAUT CTD Cast 6**

Collected sample at 75 m

**IDRONAUT CTD Cast 7**

Collected sample at 100 m

**Clean CTD Cast 2**

1745 hrs CTD lowered up to 200m

1805 hrs CTD on deck

Sampled at 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

## SK 338/12

## 13.02.2017 1030 hrs

Lat: 04°08.978´ N; Long: 86°59.907´ E; total water column depth 3900m

**Clean CTD Cast 1**

1100 hrs Clean CTD lowered up to 3900m

1400 Clean CTD on deck

Sampled at 3900m, 3500m, 3000m, 2500m, 2000m, 1800m, 1500m, 1200m,

1000m, 800m, 500m, 300m, 200m,150m, 100m, 75m, 50m,25m, 10m, 5m

**Gravity Coring**

1430 hrs lowered gravity corer

1705 hrs corer on deck and retrieved 1m core

**Clean CTD Cast 2**

1730 hrs CTD lowered up to 100m

1825 hrs CTD on deck

Sampled at 100m, 75m, 50m, 25m, 15m, 10m, 5m, 0m

All operations over and moved to next location at 1830 hrs.

## SK 338/13

## 14.02.2017 0940 hrs

Lat: 3°36.066´ N; Long: 85° 29.908´ E; total water column depth 4177m

**Clean CTD Cast 1**

1000 hrs Clean CTD lowered up to 4000 m

1300 hrs Clean CTD up on board

Sampled at 4000m, 3500m, 3000m, 2500m, 2000m, 1800m

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m and 15m

**IDRONAUT CTD Cast 4**

Collected sample at 25m

**IDRONAUT CTD Cast 5**

Collected sample at 50 m

**IDRONAUT CTD Cast 6**

Collected sample at 75 m

**IDRONAUT CTD Cast 7**

Collected sample at 100 m

**Clean CTD Cast 2**

Clean CTD lowered up to 1500m

Clean CTD on deck at 1800 hrs

Sampled at 1500m, 1200m, 1000m, 800m, 600m, 200m

**Clean CTD Cast 3**

Clean CTD lowered up to 300m

Clean CTD on deck at 1940 hrs

Sampled at 300m, 200m, 150m, 100m

**Clean CTD Cast 4**

Clean CTD lowered up to 75 m

Clean CTD on deck 2030

Sampled at 75, 50m, 25m, 10m, 5m

## SK 338/14

## 15.02.2017 1130 hrs

Lat: 03°00.048´ N; Long: 83° 59.952´ E; total water column depth 4264 m

Kevlar cable found damaged. We have cut the cable up to 250 m and reconnected to the rosette. Bottles didn't close after connecting the cable. Again removed and trying to sort out the problem. Time 1400 hrs. Problem solved.

**Clean CTD Cast 1**

1500 hrs Clean CTD lowered up to 100m

1530 Clean CTD up on board

Sampled at 100m, 3500m, 75m, 50m, 25m, 1800m, 15m, 10m, 5m , 0 m

**Clean CTD Cast 2**

1630 hrs Clean CTD lowered up to 4150m

2000 Clean CTD on deck

Sampled at 4150m, 3800m, 3500m, 3000m, 2500m, 2000m, 1800m, 1500m, 1200m, 1000m, 800m, 500m, 300m, 200m, 150m, 100m, 75m, 60m, 50m, 40m, 25m, 10m, 5m

Started moving towards next location at 2100 hrs

## SK 338/15

## 16.02.2017 0920 hrs

Lat: 3° 00.005´N; Long: 82° 29.63´ E; total water column depth 4283m

Sea is rough. Wave height and swelling is more. Found no suitable condition to lower clean CTD in to waters. Station cancelled.

## SK 338/16

## 17.02.2017 0600 hrs

Lat: 2°59.867´ N; Long: 80° 58.118´ E; total water column depth 4364m

Due to strong current and wind speed, Clean CTD sampling is cancelled.

**Gravity Coring**

Started lowering gravity corer at 1140 hrs.

Corer on deck at 1615 hrs and retrieved a 1.2 m long core.

Checked for the favourable conditions to lower the CTD. Still strong current and wind is high.

Clean Sampling cancelled and moved to next location at 1630 hrs.

## SK 338/17

## 18.02.2017 0930 hrs

Lat: 3° 58.493´ N; Long: 79° 26.071´ E; total water column depth 4301m

DP is not started. Water is falling on the generators of the engine room from the ceiling. Identified the problem and started solving the issue.

Finally, DP started at 1800 hrs.

Started lowering clean CTD at 1830 hrs to a depth of 4100 m

Kevlar cable tripped from the pulley and brought back CTD on to the deck. Found shearing of the Kevlar cable at 3 places. (1900 hrs)

It will take minimum 1-2 hours to cut the cable and in reconnection. So, decided to lower gravity corer.

**Gravity Coring**

Started lowering at 1945 hrs.

Corer on deck at 2300 hrs and retrieved a 2.7 m long core.

**Clean CTD Cast 1**

0030 hrs Clean CTD lowered up to 4100m

0320 Clean CTD on deck

Sampled at 4100m, 3800m, 3500m, 3000m, 2500m, 2000m, 1800m, 1500m, 1200m, 1000m, 800m, 500m, 300m, 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m and 15m

**IDRONAUT CTD Cast 4**

Collected sample at 25m

**IDRONAUT CTD Cast 5**

Collected sample at 50 m

**IDRONAUT CTD Cast 6**

Collected sample at 75 m

**IDRONAUT CTD Cast 7**

Collected sample at 100 m

All operations are over and started moving to next location 0500 hrs.

## SK 338/18

## 19.02.2017 1800 hrs

Lat: 3° 59.985´ N; Long: 77° 59.607´ E; total water column depth 2959 m

**Clean CTD Cast 1**

1830 hrs Clean CTD lowered up to 2800 m

2040 hrs Clean CTD up on board

Sampled at 2800m, 2500m, 2000m, 1800m, 1500m, 1200m, 1000m, 800m, 500m, 300m, 200m, 150m

**Clean CTD Cast 2**

2245 hrs Clean CTD lowered up to 300m

2330 Clean CTD on deck

Sampled at 300m, 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

All operations are over and moved to next location at 0010 hrs.

## SK 338/19

## 20.02.2017 1130 hrs

Lat: 04° 00.029´ N; Long: 76° 29.612´ E; total water column depth 3158.5 m

**Clean CTD Cast 1**

1230 hrs Clean CTD lowered up to 3000 m

1530 hrs Clean CTD up on board

Sampled at 3000m, 2800m, 2500m, 2000m, 1800m, 1500m, 1200m, 1000m, 800m, 500m, 300m, 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

**Clean CTD Cast 2**

1730 hrs Clean CTD lowered up to 75 m

1800 hrs Clean CTD up on board

Sampled at 75m, 50m, 25m, 0m

**Clean CTD Cast 3**

1815 hrs Clean CTD lowered up to 75 m

1845 hrs Clean CTD up on board

Sampled at 15m, 10m, 5m

All operations are over and moved to next location at 1850 hrs.

Due to medical Emergency of one of the scientist, we have diverted the vessel towards Cochin port for disembarkation.

## SK 338/20

## 25.02.2017 0910 hrs

Lat: 04° 01.633´ N; Long: 74° 50.601´ E; total water column depth 2618 m

**Clean CTD Cast 1**

0940 hrs Clean CTD lowered up to 2500 m

1145 hrs Clean CTD on deck

Sampled at 2500m, 2000m, 1800m, 1500m,

**Clean CTD Cast 2**

1340 hrs Clean CTD lowered up to 1200 m

1440 hrs Clean CTD on deck

Sampled at 1200m, 1000m, 800m, 600m, 300m,

**Clean CTD Cast 3**

1630 hrs Clean CTD lowered up to 200 m

1650 hrs Clean CTD up on board

Sampled at 200m, 150m, 100m, 75m,

**Clean CTD Cast 4**

1745 hrs Clean CTD lowered up to 200 m

1755 hrs Clean CTD on deck

Sampled at 50m, 25m, 10m, 2m

**IDRONAUT CTD Cast 1**

Sampled at surface 0 m

**IDRONAUT CTD Cast 2**

Collected sample at 5 m

**IDRONAUT CTD Cast 3**

Collected sample at 10 m and 15m

**IDRONAUT CTD Cast 4**

Collected sample at 25m

**IDRONAUT CTD Cast 5**

Collected sample at 50 m

**IDRONAUT CTD Cast 6**

Collected sample at 75 m

**IDRONAUT CTD Cast 7**

Collected sample at 100 m

**Gravity Coring**

Started lowering corer at 1815 hrs

Corer on deck at 2015 hrs and retrieved a 3.2 m long core.

All operations are over and moved to next location at 2040 hrs.

## SK 338/21

## 26.02.2017 1710 hrs

Lat: 06° 19.332´ N; Long: 74° 28.031´ E; total water column depth 2752.2 m

**Clean CTD Cast 1**

1730 hrs Clean CTD lowered up to 2600 m

1915hrs Clean CTD on deck

Sampled at 2600m, 2200m, 1800m, 1500m, 1200m, 1000m, 800m, 500m, 300m, 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

**IDRONAUT CTD Cast 1**

1930 hrs Clean CTD lowered up to 50 m

1950 hrs Clean CTD up on board

Sampled at 50m, 25m

**IDRONAUT CTD Cast 2**

1955 hrs Clean CTD lowered up to 15 m

2015 hrs Clean CTD up on board

Sampled at 15m, 10m

**IDRONAUT CTD Cast 3**

2020 hrs Clean CTD lowered up to 5 m

2030 hrs Clean CTD up on board

Sampled at 5m, 0m

All operations are over and moved to next location at 2035 hrs.

## SK 338/22

## 27.02.2017 1700 hrs

Lat: 08°26.183´ N; Long: 74° 06.108´ E; total water column depth 2759.6 m

**Clean CTD Cast 1**

1740 hrs Clean CTD lowered up to 2600 m

1920 hrs Clean CTD on deck

Sampled at 2600m, 2200m, 1800m, 1500m, 1200m, 1000m, 800m, 500m, 300m, 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

**IDRONAUT CTD Cast 1**

1930 hrs Clean CTD lowered up to 50 m

1950 hrs Clean CTD up on board

Sampled at 50m, 25m

**IDRONAUT CTD Cast 2**

1955 hrs Clean CTD lowered up to 15 m

2015 hrs Clean CTD up on board

Sampled at 15m, 10m

**IDRONAUT CTD Cast 3**

2020 hrs Clean CTD lowered up to 5 m

2030 hrs Clean CTD up on board

Sampled at 5m, 0m

Ship sailing is delayed due to the entrance of water in the steering room.

All operations are over and moved to next location at 0030 hrs on 28.02.2017.

## SK 338/23

## 28.02.2017 1600 hrs

Lat: 09°45.908´ N; Long: 74° 20.671´ E; total water column depth 2566 m

Due to strong current and wind speed, clean CTD operation is aborted at 1730 hrs.

**Gravity Coring**

Started lowering gravity corer at 1730 hrs.

Corer on deck at 2030 hrs and retrieved a 4.5 m long core.

All operations are over and moved to next location at 2045 hrs.

## SK 338/24

## 01.03.2017 0900 hrs

Lat: 11° 01.841´ N; Long: 74° 01.94´ E; total water column depth 2070 m

Kevlar cable found damaged at 10m. Stopped lowering clean CTD to solve the issue.

Clean CTD on deck at 0930 hrs.

Started lowering IDRONAUT CTD at 0945 hrs.

**IDRONAUT CTD Cast 1**

0945 hrs Clean CTD lowered up to 50 m

1000 hrs Clean CTD up on board

Sampled at 50m, 25m

**IDRONAUT CTD Cast 2**

1010 hrs Clean CTD lowered up to 15 m

1020 hrs Clean CTD up on board

Sampled at 15m, 10m

**IDRONAUT CTD Cast 3**

1030 hrs Clean CTD lowered up to 5 m

1040 hrs Clean CTD up on board

Sampled at 5m, 0m

**Clean CTD Cast 1**

1045 hrs Clean CTD lowered up to 1800 m

1230 hrs Clean CTD up on board

Sampled at 1800m, 1600m, 1400m, 1200m, 1000m, 800m, 600m, 500m, 300m, 200m, 150m, 100m, 75m, 50m, 25m, 10m, 5m

**McLANE**

Planned to operate McLANE at 200 m and 500 m

Integration time set is 2 hours. Flow rate 6L/minute

Sample volume to be pumped 800 L per 2 hours.

McLANE started lowering at 1240 hrs. McLANE reached 200 m at 1255hrs.

Pump started as per the pre-defined time 1300 hrs.

McLANE started heaving at 1500 hrs.

McLANE on deck at 1510 hrs.

Filters collected were 33 micron, 0.8 micron and 0.45 micron. A total of 702 L of seawater were pumped through the filter.

Started lowering McLANE to a depth of 500 m at 1515 hrs.

Pump started as per the pre-defined time 1540 hrs.

McLANE started heaving at 1745 hrs.

McLANE on deck at 1820 hrs.

A total of 711 L of seawater was pumped through filters and collected 33, 0.8, 0.45 micron filters.

**Gravity Coring**

Started lowering gravity corer at 1850 hrs.

Corer on deck at 2100 hrs and retrieved a 4.1 m long core

All operations are over and moved to next location at 2110 hrs.

## SK 338/25

## 02.03.2017 1355 hrs

Lat: 12° 56.411´ N; Long: 73° 27.507´ E; total water column depth 1733.9 m

**McLANE**

Planned to operate McLANE at 100 m

Integration time set is 2 hours. Flow rate 6L/minute

Sample volume to be pumped 800 L per 2 hours.

McLANE started lowering at 1420 hrs. McLANE reached 100 m at 1430hrs.

Pump started as per the pre-defined time 1435 hrs.

McLANE started heaving at 1635 hrs.

McLANE on deck at 1645 hrs.

Filters collected were 33 micron, 0.8 micron and 0.45 micron. A total of 735.65 L of seawater pumped through the filter.

**Gravity Coring**

Started lowering gravity corer at 1655 hrs.

Corer on deck at 1900 hrs and retrieved a 3.5 m long core

Drifted a little distance from the current location to collect one more core from this location.

Lat: 12° 56.496´ N; Long: 73° 27.521´ E; total water column depth 1723.4 m

Started lowering gravity corer at 1910 hrs.

Corer on deck at 1900 hrs and retrieved a 4.1 m long core

All operations of the SK 338 cruise are over and moved to Goa port at 2015 hrs on 02.03.2017.

**Analytical Procedures: -**

Samples collected during the cruise SK-338 cruise are given below: -

1) Trace Metals and their Isotopes: A 3 X 1L LDPE and 1 X 1L PP bottles are used for collecting seawater samples by pressurized filtration through 0.2μm Acropak filters inside a class – 1000 clean van for various bioactive trace elemental concentrations and as well as to study their isotopic composition. Onboard analysis of Zn was carried out using Zn Flow injection system (Zn-FIS).

2) Neodymium and Hafnium isotopes: About 60 L to 200 L of seawater was passed after pressurized filtration through 0.2 Micron PALL Acropak filters for Nd and Hf isotopic compositions to understand the various water masses in the present cruise track.

3) McLANE water pumping system was used for the first time to collect particulate matter at different depths (100m, 500m and 1000m) of water column respectively. Around 700 L of seawater was passed through filters of varying size 33 micron, 0.8 micron and 0.45 micron which were kept inside a McLANE water pumping system and at each depth 33, 0.8 and 0.45 micron filter papers are collected.

4) $^{14}C$: About 500 mL seawater is collected for C-14 measurements.

5) pH & Salinity: In 2 X 60 mL LDPE bottles, unfiltered seawater samples were collected for onboard measurement of pH and salinity. pH was measured using TIAMO software using I-ECOTRODE glass electrode and salinity is measured using AUTO SAL available on the ship.

6) Nutrients: 150 mL of unfiltered seawater samples were collected for nutrient (Nitrite, Nitrate, Phosphate and Silicate) measurements onboard. Analysis for Nitrate, Nitrite and Silicate are performed onboard using SKALAR auto analyzer.

7) $\delta^{18}O$: 60 mL of unfiltered seawater is collected for stable oxygen isotope measurements.

8) DOC: 40 mL of seawater is collected for DOC (Dissolved Organic Carbon) measurement.

9) Dissolved Oxygen: 60 mL of unfiltered seawater samples are collected for dissolved Oxygen measurements.

10) $\Sigma CO_2$: About 60 mL of unfiltered seawater samples were collected for $\Sigma CO_2$measurements.

11) Sediment Core: Gravity Corer was used to recover sediment cores from different locations.

12) Aerosols: PM 2.5 and PM 10 air samples were collected from High Volume Air Sampler on PTFE filter papers. Samples were collected during sailing for every 20-24 hours. A total of 60 numbers of samples were collected.

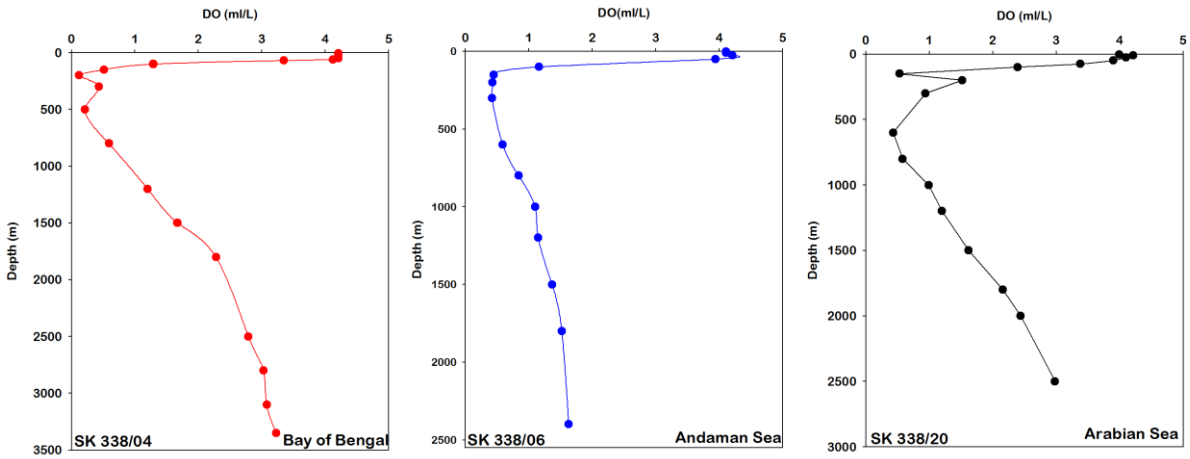
Ambient Ion Monitoring System (AIMS) was operated from 28/01/2017 to 03/03/2017 which provided hourly measurements of anions and cations present. A total of 1500 samples were collected.

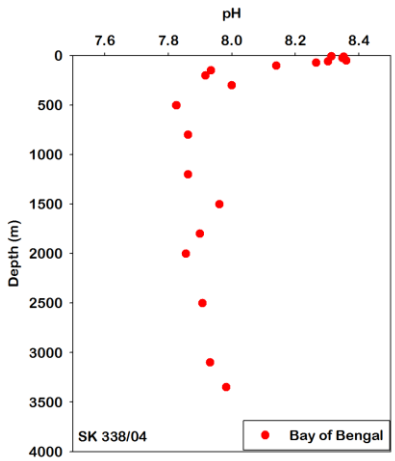
13) Rain water: Rain water samples were collected whenever available using a funnel system for stable isotopes and other miscellaneous measurements. A total of 5 samples are collected during the cruise time.

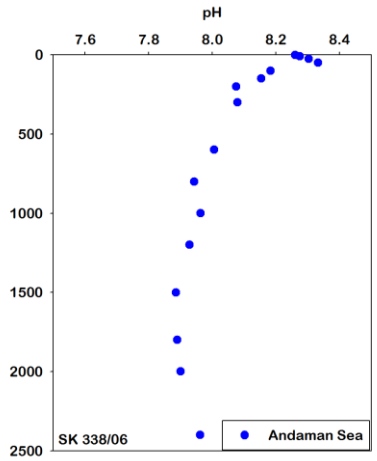
14) Alkalinity: 60 ml of unfiltered seawater samples collected and measured onboard.

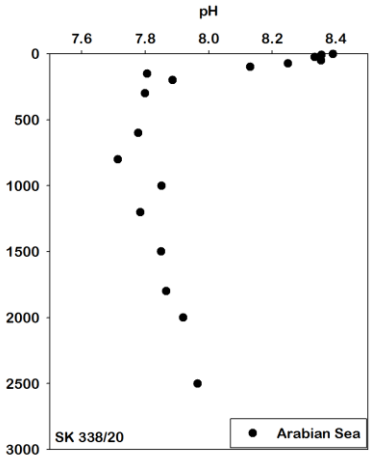
**Results**

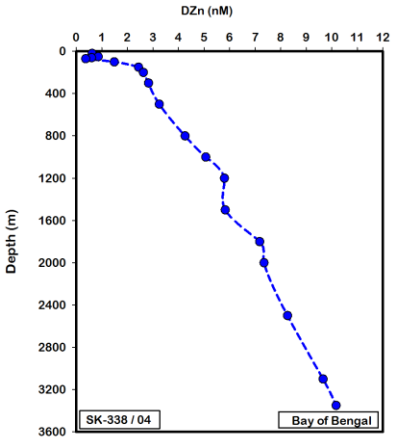
The following figures and plots show selected results of the on board measurements and basic parameters data during the cruise time SK-338.

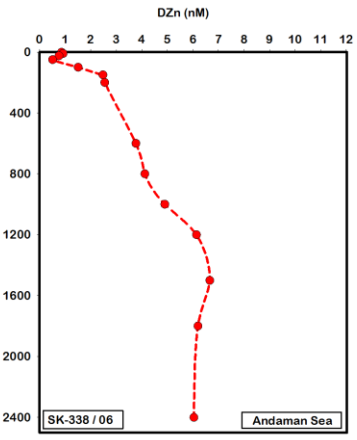


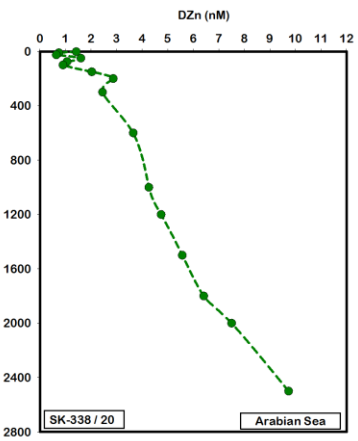

pH
7.6 7.8 8.0 8.2 8.4
Depth (m)
SK 338/04
Bay of Bengal

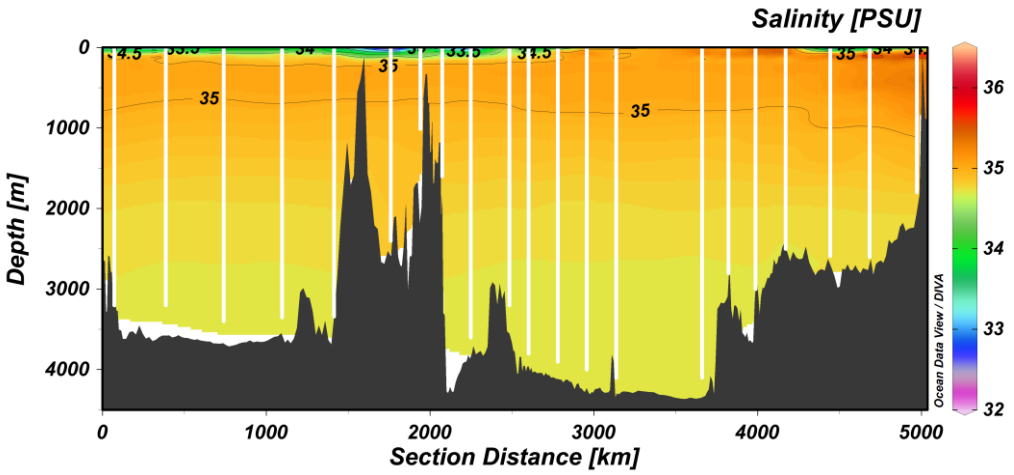

pH
7.6 7.8 8.0 8.2 8.4
SK 338/06
Andaman Sea


pH
7.6 7.8 8.0 8.2 8.4
SK 338/20
Arabian Sea


DZn (nM)
Depth (m)
SK-338 / 04
Bay of Bengal


DZn (nM)
SK-338 / 06
Andaman Sea


DZn (nM)
SK-338 / 20
Arabian Sea


Salinity [PSU]
Depth [m]
Section Distance [km]
Ocean Data View / DtVA

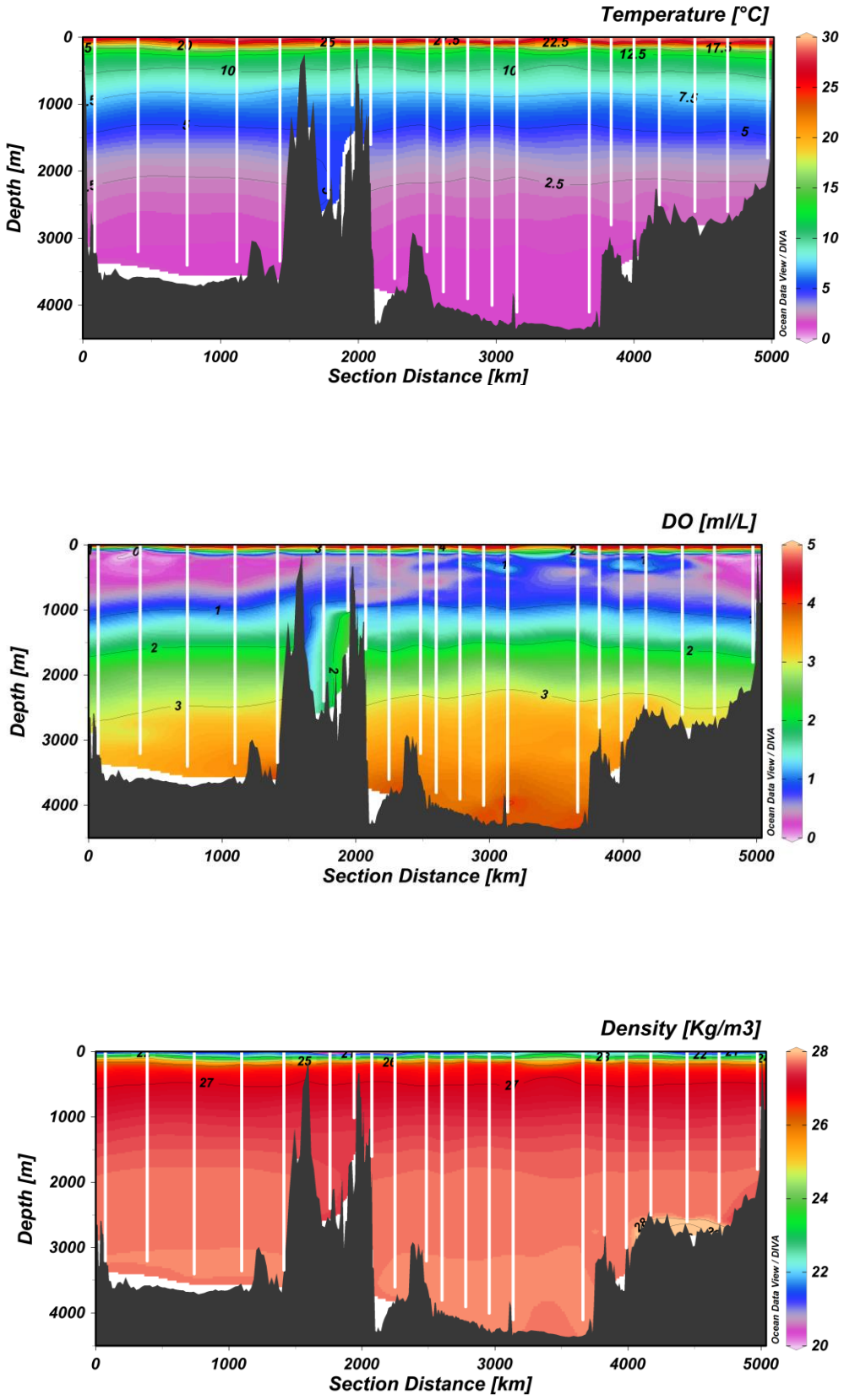



**Figure: Selected plots for various parameters during SK 338.**

**Scientific observations**

**Atmospheric input:** Perhaps the most important atmospheric input is rainfall that carries particles and aerosols and contributes buoyancy to surface waters. The region does notreceive significant Saharan dust flux. However, input of continental dust and of rainfall during the monsoon and under the influence of episodic events (cyclones, fires) requires further investigation. Anthropogenic inputs in the form of acid rain are significant.

**Productivity controls:** Productivity in the Arabian Sea is controlled by upwelling associated with Southwest monsoon conditions. Extent of productivity is reflected in the sub seasurface anoxic conditions. Thus, it is very important to understand the biogeochemicalbehaviour of trace elements as a function of productivity.

**Indonesian through flow:** The Indonesian Through Flow (ITF) represents a major element of global meridional overturning circulation, as warm surface water from the Pacific moves into the Indian Ocean. Part of the ITF water is influenced by sediment-water exchange reactions as it passes over the shallow shelf regions surrounding Indonesia and Southeast Asia. Sources and sinks of TEIs associated with these exchange processes should be quantified. Exchange of water across the Indonesian archipelago between the old Pacific waters and younger Indian Ocean water of different biogeochemical signatures can be constrained by stable isotopes (C, N, O).

**Residence time of surface water:** The Arabian Sea is north eastern basin of the Indian Ocean Where concentrations are affected by external fluxes and internal cycling. A key parameter in evaluating these effects is the residence time of the surface water.

**Deep sediment sources:** Paleo-depositional and diagenetic proxies of productivity, climate, continental weathering, hydrothermal and geothermal inputs are traceable by the analysis of different inorganic and organic proxies. Sediment cores collected from the Arabian Sea and the Indian Ocean region will help in understanding these processes.

**Acknowledgements**

I am highly grateful and thankful to Dr. M Rajeevan Secretary, MoES for his generous support and encouragement to the GEOTRACES scientific programme. On behalf of all scientific participants, I thank ship staff of ORV Sagar Kanya for their cooperation during the SK-338 cruise. I am grateful to Dr. M. Ravichandran, Director NCAOR for his support and encouragement in providing ship time for this cruise. The Norinco engineers onboard were very kind and helpful in our various deck operations, onboard measurements and scientific requirements. I would like to thank Dr. M. M. Subramaniam, NCAOR and its ship cell, who took special interest in our scientific requirements for this cruise and were very supportive with respect to our requirements for this GEOTRACES cruise and made appropriate logistics arrangements and finally, I would like to thank all scientific participants of this cruise from various institutions, who with their dedicated hard work and cooperation completed this cruise successfully.

**(Venkatesh Chinni)**

# Chief Scientist

Physical Research Laboratory

Navrangpura, Ahmedabad, 380009

## Annexure – I

## SK-338 Participants

**Physical Research Laboratory, Ahmedabad**

1. Mr. Venkatesh Chinni, (Chief Scientist)
2. Mr. Abhishek Tiwari, (Dy. Chief Scientist)
3. Mr. Damodara Rao Karri (Post Doctoral Fellow)
4. Mr. Mahesh Gaddam (Scientific Assistant)
5. Ms. Priyanka Jha (Project Associate)
6. Mr. Harsh Raj (Junior Research Fellow)
7. Mr. Namandeep Singh (Junior Research Fellow)
8. Ms. Romi Nambiar (Project Associate)
9. Ms. Sannjukta Dhar (Project Associate)
10. Ms. Dipika Jain (Post Graduate Student)

**National Institute of Oceanography, Regional Centre, Vishakhapatnam**

11. Mr. Sampath Kumar G (Project Assistant)
12. Ms. Navita Buddiga (Project Assistant)

13. Mr. Narasimha Rao D (Project Assistant)

14. Mr. Durga Prasad M (Project Assistant)

**Mangalore University, Mangalore**

15. Mr. Arif Ahmed (Junior Research fellow)

**Engineers - M/s Norinco Pvt. Ltd**

16. Mr. Vishwanathan (Service Engineer)

17. Mr. V. C. Sarathchandran (Service Engineer)

18. Mr. Bijesh (Service Engineer)

19. Mr. Ramesh R (Service Engineer)

20. Mr. Ramesh M (Service Engineer)

**National Centre for Antarctica and Ocean Research, Goa**

21. Mr. Pawan Shirodkar (Shipboard Assistant)

# Annexure – II

Cruise Report – SK 338

Submitted by Mangalore University - Mangalore

Arif Ahmed

**Objectives of samples collected during cruise (SK – 338)**

Two core samples were collected one in Andaman and another off Goa. These samples are meant to study sources of sediments by mineral magnetic, sedimentological, Geochemicl and Paleontological approaches to understand the Paleo-Oceanographic aspects of the distal ends of Bay of Bengal and Arabian Sea.

Further, we catch atmospheric aerosols along the cruise track to study the atmospheric input and their impact on climate.

# Technical Observation and Suggestions

## ORV Sagar Kanya Cruise # 338

1) Water is leaking continuously in the decks as well as in the labs during the entire cruise.

2) Wash basins are not in the working condition of the chemical lab as well as auto analyzer lab during the entire cruise.

3) The core lift in the wet lab is not in the working condition throughout the cruise SK 338.

4) The fume hoods situated at the both starboard and port side wet labs are not working that efficiently. Suction capacity has to be improved.

5) The calibration settings for the SKALAR auto analyzer have to be rechecked and needed to be modified according to their concentrations in the seawater.

Silicate 0 – 160 µM.

$NO_3$+$NO_2$ 0 – 40

NO2 0 – 8

Phosphate 0 – 4.