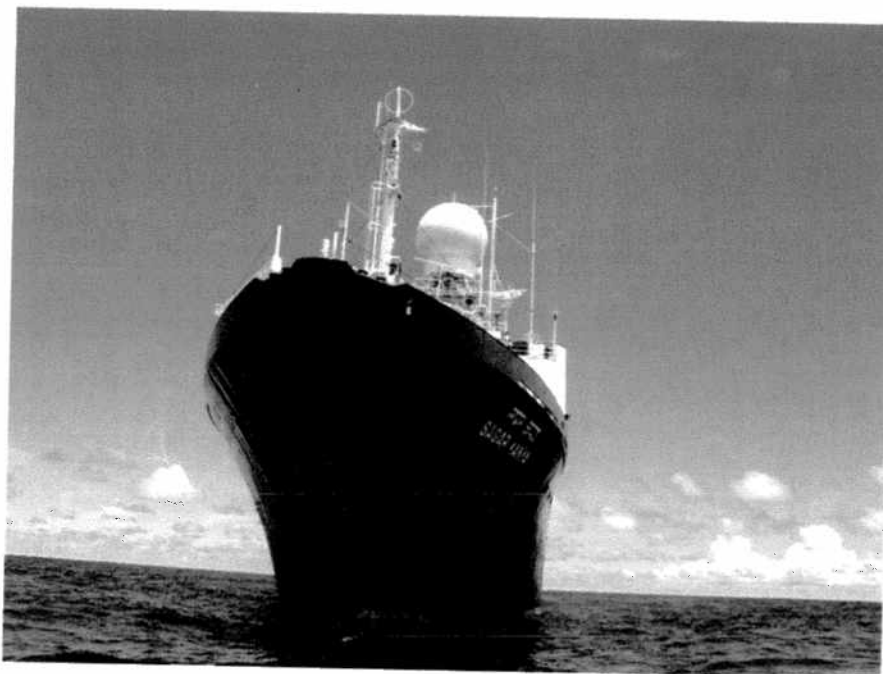


**NATIONAL CENTRE FOR ANTARCTIC AND OCEAN RESEARCH**  
HEADLAND SADA, VASCO-DA-GAMA  
GOA – 403804.



**ORV SAGAR KANYA**

**CRUISE NO. SK -216**

**REPORT**

**AREA OF OPERATION**

**Coastal waters and continental margin of the southeast and southwest  
coasts of India covering the parts of Bay of Bengal and Arabian Sea**



**3<sup>rd</sup> January 15<sup>th</sup> January 2005**  
**Goa – Chennai**

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## **Embarkation**

**Port of embarkation:** Goa

**Date:** 03/01/2005

## **Disembarkation**

**Port of Disembarkation:** Chennai

**Date:** 15/01/2005

**Objectives:** To study the significant changes occurred in the coastal waters and continental margin of the southeast and southwest coasts of India due to the impact of Tsunami waves.

## **Participating organizations:**

1. National Centre for Antarctic and Ocean Research (NCAOR), Goa
2. National Institute of Oceanography (NIO), Goa

## **Participants**

### **NCAOR:**

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Vessel started sailing from Marmagao Goa at 1912 hours on 3<sup>rd</sup> January, 2005. NCAOR and NIO were collaborated for a detailed investigation of the geological, biological, physical and chemical changes occurred in the southwest and southeast coast of India due to the impact of Tsunami waves arrived on 26<sup>th</sup> Dec, 04. Different scientific instruments were used to collect the essential data sets required to materialize the objectives of the present investigation. Gravity Corer, Grab sampler, Zooplankton Net, Conductivity Temperature Depth (CTD), Expendable Bathythermograph (XBT), Acoustic Doppler Current Profiler, Thermosalinograph, Wave Recorder, Sub-Bottom Profiler, Gravimeter and Hydrosweep were the instruments used in present study.

Kochi, Kollam and Kanyakumari (southwest coast) Nagapattinam, Cudallore and Chennai (southeast coast) were selected as the prime areas for this study since human life and property in these regions were more affected by the impact of recently occurred Tsunami waves.

Details of CTD and Water sampling operations						
St. No	Date/Time	CTD operations Station Depth	CTD lowered depth	Latitude	Longitude	Remarks
1	4 <sup>th</sup> Jan, 05/0345 hrs	490m	412m	14°59' N	72° 54' E	Operations were carried out by using the CTD (make: SBE 9/11; accuracy: temperature +0.001°C, conductivity +0.0001S/m and depth +0.005% of full scale) Water samples were collected from different depths such as 0, 50, 100, 150, 200 and 400m by Rossette water sampler attached with CTD.
2	4 <sup>th</sup> Jan05/1815 hrs	573m	478m	13°34'N	73°23' E	
3	5 <sup>th</sup> Jan05/0930hrs	500m	400m	12°30'N	74° 17' E	
4	5 <sup>th</sup> Jan05/1215hrs	511m	400m	10°30'N	75°22' E	
5	6 <sup>th</sup> Jan05/0920 hrs	500m	400m	9°56'N	75°33' E	
6	7 <sup>th</sup> Jan05/1730 hrs	320m	300m	8°52.88'N	75°56.57' E	
7	8 <sup>th</sup> Jan05/1530 hrs	200m	150m	7°23.2'N	77°48.23' E	
8	9 <sup>th</sup> Jan05/0000 hrs	2770m	400m	6°26.55'N	78°6.48' E	
9	9 <sup>th</sup> Jan05/0935 hrs	3800m	500m	5°27.48'N	78°23.49' E	
10	13 <sup>th</sup> Jan05/0100hrs	200m	150m	10°44.748'N	80°13.087' E	
11	13 <sup>th</sup> Jan05/0400hrs	300m	250m	10°45'N	80°21' E	
12	13 <sup>th</sup> Jan05/1040hrs	500m	400m	11°14.26'N	80°06.2' E	
13	14 <sup>th</sup> Jan05/0200hrs	550m	400m	11°43'N	80°1.97' E	
14	14 <sup>th</sup> Jan05/0800hrs	680m	400m	12°08'N	80°17' E	
15	14 <sup>th</sup> Jan05/1328hrs	500m	400m	12°29.45'N	80°40' E	
16	14 <sup>th</sup> Jan05/1732hrs	3200m	400m	12°48.73'N	80°52.23' E	
17	14 <sup>th</sup> Jan05/2138hrs	3348m	400m	13°05'N	81°05' E	
18	15 <sup>th</sup> Jan05/0053hrs	510m	400m	13°06'N	80°42.49' E	

Details of XBT Operations				
St No.	Date/Time	Latitude	Longitude	Remarks
1	4 <sup>th</sup> Jan05/1400hrs	14°6'N	73°12'E	By launching the Sippican T <sub>7</sub> XBT probes
2	5 <sup>th</sup> Jan05/0247hrs	12°39'N	73°55'E	
3	5 <sup>th</sup> Jan05/1519hrs	11°22'N	74°45'E	
4	9 <sup>th</sup> Jan05/1744hrs	5°29'N	79°0'E	
5	9 <sup>th</sup> Jan05/2351 hrs	5°34'N	79°39'E	
6	10 <sup>th</sup> Jan05/0914hrs	5°41'N	80°39'E	
7	10 <sup>th</sup> Jan05/1757hrs	6°02'N	81°32'E	
8	11 <sup>th</sup> Jan05/0505hrs	7°00'N	82°01'E	
9	11 <sup>th</sup> Jan05/1325hrs	7°48'N	81°53'E	
10	11 <sup>th</sup> Jan05/2315hrs	8°52'N	81°23'E	

Details of Phytoplankton's observations					
St. No.	Date/Time	Operation water depth	Latitude	Longitude	Remarks
1	3 <sup>rd</sup> Jan05/2330hrs	Surface	15° 14'N	73°22'E	
2	4 <sup>th</sup> Jan05/0400hrs	O m, 50m, 100m, 150m, 200m and 400m	15° N	72°63'E	
3	4 <sup>th</sup> Jan05/1030hrs	Surface	14°28' N	73°04'E	
4	4 <sup>th</sup> Jan05/1730hrs	Surface	13°36' N	70°23'E	
5	5 <sup>th</sup> Jan05/02005hrs	Surface	12°39' N	70°23'E	
6	5 <sup>th</sup> Jan05/0735hrs	O m, 50m, 100m, 150m, 200m and 400m	12°N	74°17'E	
7	5 <sup>th</sup> Jan05/1500hrs	Surface	11°24' N	74°44'E	
8	5 <sup>th</sup> Jan05/2345hrs	Surface	10°13' N	75°22'E	
9	6 <sup>th</sup> Jan05/0700hrs	Surface	10°09' N	76°05'E	
10	6 <sup>th</sup> Jan05/1500hrs	Surface	9°58' N	75°35'E	
11	6 <sup>th</sup> Jan05/2400hrs	Surface	9°32' N	75°55'E	
12	7 <sup>th</sup> Jan05/0700hrs	Surface	9° N	76°25'E	
13	7 <sup>th</sup> Jan05/1530hrs	O m, 50m, 100m, 150m and 200m	8°52' N	75°56'E	
14	8 <sup>th</sup> Jan05/0450hrs	Surface	8°01'N	77°48'E	
15	9 <sup>th</sup> Jan05/0010hrs	O m, 50m, 100m, 150m, 200m and 400m	6°26'N	78°06'E	
16	9 <sup>th</sup> Jan05/0945hrs	O m, 50m, 100m, 150m, 200m and 400m	5°27'N	78°23'E	
17	9 <sup>th</sup> Jan05/1750hrs	Surface	5°29'N	79°E	
18	9 <sup>th</sup> Jan05/2345hrs	Surface	5°34'N	79°39'E	
19	10 <sup>th</sup> Jan05/0630hrs	Surface	5°40'N	80°20'E	
20	10 <sup>th</sup> Jan05/1345hrs	Surface	5°46'N	81°7'E	
21	11 <sup>th</sup> Jan05/0500hrs	Surface	7°8'N	82°1'E	
22	11 <sup>th</sup> Jan05/1330hrs	Surface	7°48'N	81°53'E	
23	11 <sup>th</sup> Jan05/2045hrs	Surface	8°35'N	81°33'E	
24	12 <sup>th</sup> Jan05/0300hrs	Surface	9°16'N	81°6'E	
25	12 <sup>th</sup> Jan05/0910hrs	Surface	9°54'N	80°40'E	
26	12 <sup>th</sup> Jan05/1300hrs	Surface	10°38'N	80°08'E	
27	13 <sup>th</sup> Jan05/0200hrs	O m, 50m, 100m, 150m	10°44'N	80°11'E	
28	13 <sup>th</sup> Jan05/0500hrs	O m, 50m, 100m, 150m and 200m	10°44'N	80°20'E	
29	13 <sup>th</sup> Jan05/1140hrs	O m, 50m, 100m, 150m and 200m and 400	11°14'N	80°06'E	
30	14 <sup>th</sup> Jan05/0300hrs	O m, 50m, 100m, 150m and 200m and 400	11°42'N	79°58'E	
31	14 <sup>th</sup> Jan05/0600hrs	Surface	11°42'N	80°41'E	
32	14 <sup>th</sup> Jan05/0900hrs	O m, 50m, 100m, 150m and 200m and 400	12°08'N	80°17'E	
33	14 <sup>th</sup> Jan05/1430hrs	O m, 50m, 100m, 150m and 200m and 400	12°29'N	80°40'E	
34	14 <sup>th</sup> Jan05/1820hrs	O m, 50m, 100m, 150m and 200m and 400	12°48.73'N	80°52.21'E	
35	14 <sup>th</sup> Jan05/2230hrs	O m, 50m, 100m, 150m and 200m and 400	13°05'N	81°05'E	
36	15 <sup>th</sup> Jan05/0145hrs	O m, 50m, 100m, 150m and 200m and 400	13°06'N	81°42.49'E	

<b>Details of Zooplankton Net operations</b>					
<b>St. No.</b>	<b>Date/Time</b>	<b>Operation water depth</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Remarks</b>
1	4 <sup>th</sup> Jan05/0400hrs	400m & 150m	15° N	72°53'E	200micron zooplankton net were used to collected the samples.
2	5 <sup>th</sup> Jan05/0735hrs	400m & 150m	12° N	74°17'E	
3	6 <sup>th</sup> Jan05/1515hrs	400m & 150m	9°58' N	75°35'E	
4	7 <sup>th</sup> Jan05/1530hrs	150m	8°52' N	75°56'E	
5	8 <sup>th</sup> Jan05/15005hrs	150m	7°23' N	77°48'E	
6	9 <sup>th</sup> Jan05/0010hrs	150m	6°26'N	78°06'E	
7	9 <sup>th</sup> Jan05/0945hrs	150m	5°27' N	78°23'E	
8	12 <sup>th</sup> Jan05/2035hrs	Surface	10°44.96' N	80°02.70'E	100micron zooplankton net were used
9	12 <sup>th</sup> Jan05/2130hrs	Surface	10°45.06' N	80°06.62'E	100micron zooplankton net were used
10	12 <sup>th</sup> Jan05/2215hrs	Surface	10°46.9' N	80°10.36'E	100micron zooplankton net were used
11	12 <sup>th</sup> Jan05/2245hrs	Surface	10°44.89' N	80°11.65'E	100micron zooplankton net were used
12	12 <sup>th</sup> Jan05/2345hrs	Surface	10°44.56' N	80°12.71'E	100micron zooplankton net were used
13	13 <sup>th</sup> Jan05/0040hrs	Surface	10°44.79' N	80°13.24'E	100micron zooplankton net were used
14	13 <sup>th</sup> Jan05/0430hrs	Surface and 200m	10°44.60' N	80°20.50'E	100micron zooplankton net were used
15	13 <sup>th</sup> Jan05/1700hrs	Surface	11°42.77' N	79°51.13'E	100micron zooplankton net were used
16	13 <sup>th</sup> Jan05/2350hrs	Surface	11°42.60' N	79°59.50'E	100micron zooplankton net were used
17	14 <sup>th</sup> Jan05/1410hrs	Surface and 200m	11°42.78' N	80°01.85'E	100micron zooplankton net were used

<b>Details of Geological Sampling</b>						
<b>St. No.</b>	<b>Corer used</b>	<b>Date/Time</b>	<b>Depth</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Remarks</b>
5	Small Gravity Corer	6 <sup>th</sup> Jan05/0810hrs	14.10m	10° 08.70'N	76°05.25'E	69 cm core length
6	Grab Corer	6 <sup>th</sup> Jan05/0940hrs	25.16m	10° 07.79'N	76°02.02'E	
7	Gravity Corer	6 <sup>th</sup> Jan05/1150hrs	50.08m	10° 02.84'N	75°48.60'E	120 cm core length
8	Grab Corer	6 <sup>th</sup> Jan05/1325hrs	100.6m	09° 058.62'N	75°38.02'E	
9	Grab Corer	6 <sup>th</sup> Jan05/1530hrs	165m	09° 058.23'N	75°35.68'E	
10	Grab Corer	6 <sup>th</sup> Jan05/1815hrs	478m	09° 58.03'N	75°32.96'E	
11	Short Gravity corer	7 <sup>th</sup> Jan05/0735hrs	11.4m	08° 59.81'N	76°28.31'E	62 cm core length
12	Grab	7 <sup>th</sup> Jan05/0905hrs	27.1m	08° 59.05'N	76°23.87'E	
13	Grab	7 <sup>th</sup> Jan05/1045hrs	50.3m	08° 57.52'N	76°14.19'E	Grab sample collected after two attempts of gravity corer
14	Grab	7 <sup>th</sup> Jan05/1230hrs	75.2m	08° 55.11'N	76°04.35'E	
15	Grab	7 <sup>th</sup> Jan05/13405hrs	104.5m	08° 54.50'N	76°01.21'E	
16	Grab	7 <sup>th</sup> Jan05/1430hrs	178.9m	08° 54.29'N	75°59.69'E	
17	Grab	7 <sup>th</sup> Jan05/1615hrs	312m	08° 53.78'N	75°55.14'E	
18	Grab	8 <sup>th</sup> Jan05/0800hrs	17.59m	08° 03.60'N	77°32.01'E	Grab sample collected after one attempt of gravity corer
19	Grab	8 <sup>th</sup> Jan05/1100hrs	49.80m	07° 46.32'N	77°37.97'E	Grab sample collected after one attempt of gravity corer
20	Grab	8 <sup>th</sup> Jan05/1400hrs	99.63m	07° 29.36'N	77°45.21'E	
21	Grab	8 <sup>th</sup> Jan05/1615hrs	208.3m	07° 21.31'N	77°46.97'E	
22	Grab	12 <sup>th</sup> Jan05/1855hrs	09.0m	10° 44.85'N	79°55.54'E	Grab sample collected after one attempt of gravity corer
23	Grab	12 <sup>th</sup> Jan05/2035hrs	27.50m	10° 44.96'N	80°02.70'E	
24	Grab	12 <sup>th</sup> Jan05/2130hrs	50.0m	10° 45.06'N	80°06.62'E	
25	Grab	12 <sup>th</sup> Jan05/2215hrs	75m	10° 46.9'N	80°10.36'E	
26	Grab	12 <sup>th</sup> Jan05/2245hrs	104.2m	10° 44.89'N	80°11.65'E	
27	Grab	12 <sup>th</sup> Jan05/2345hrs	156.2m	10° 44.56'N	80°12.71'E	
28	Gravity Corer	13 <sup>th</sup> Jan05/0040hrs	191.4m	10° 44.79'N	80°13.24'E	
29	Grab	13 <sup>th</sup> Jan05/0230hrs	251m	10° 45.32'N	80°17.63'E	
30	Grab	13 <sup>th</sup> Jan05/0500hrs	273m	10° 44.29'N	80°20.19'E	Grab sample collected in two attempts



St. No.	Corer used	Date/Time	Depth	Latitude	Longitude	Remarks
31	Grab	13 <sup>th</sup> Jan05/1700hrs	10.08m	11° 42.77'N	79°48.73'E	Grab sample collected after one attempt of gravity corer
32	Grab	13 <sup>th</sup> Jan05/1820hrs	17m	11° 42.37'N	79°51.13'E	Grab sample collected in third attempts
33	Grab	13 <sup>th</sup> Jan05/1930hrs	25.3m	11° 43.14'N	79°53.49'E	
34	Grab	13 <sup>th</sup> Jan05/2110hrs	65m	11° 42.98'N	79°58.96'E	
35	Grab	13 <sup>th</sup> Jan05/2150hrs	71.5m	11° 42.92'N	79°59.20'E	
36	Grab	13 <sup>th</sup> Jan05/2350hrs	94m	11° 42.60'N	79°59.50'E	
37	Gravity corer	14 <sup>th</sup> Jan05/0125hrs	186m	11° 42.86'N	79°59.97'E	Collected samples by operating gravity corer after two attempts of grab corer. Core length 96 cm
38	Grab sampling	14 <sup>th</sup> Jan05/0250hrs	208m	11° 43.09'N	80°00.31'E	
39	Grab sampling	14 <sup>th</sup> Jan05/0250hrs	244m	11° 43.25'N	80°00.67'E	Silt
40	Grab sampling	15 <sup>th</sup> Jan05/0225hrs	198.2m	13° 06.8'N	80°35.4'E	Sample collected in two attempt
41	Grab sampling	15 <sup>th</sup> Jan05/0315hrs	144 m	13° 06.91'N	80°33.17'E	Silty clay
42	Grab sampling	15 <sup>th</sup> Jan05/0400hrs	102.6 m	13° 06.79'N	80°31.80'E	Silty sand
43	Core sampling	15 <sup>th</sup> Jan05/0500hrs	50m	13° 06.67'N	80°26.28'E	Silty sand core length 2.72m
44	Grab sampling	15 <sup>th</sup> Jan05/0600hrs	24 m	13° 07.02'N	80°24.00'E	Sand
45	Grab sampling	15 <sup>th</sup> Jan05/0700hrs	14 m	13° 06.57'N	80°20.51'E	Sand

**Other operations:** Acoustic Doppler Current Profiler (ADCP), Thermosalinograph, Wave Recorder, Sub bottom Profiler, Gravimeter and Hydrosweep were operated throughout the cruise track from Goa to Chennai. All phytoplankton observations are showed in the table given in page no. 4.

#### 4<sup>th</sup> January 2005

First CTD and Zooplankton Net observations were carried out at 14° 59' N, 72° 54' E. Second CTD station was at 13° 34'N 73° 23' E. Water samples were collected at different depths for chemical and biological analysis. XBT was launched at 14° 6' N, 73° 12' E.

**5<sup>th</sup> January, 2005**

Third and fourth CTD operations were carried out at 12° 7' N, 74° 17.76'E and 10°30'N, 75°22'E respectively. Zooplankton Net was operated at the third CTD station.

**6<sup>th</sup> January, 2005**

The geological sampling was carried out off Kochi from 14m, 25m, 50m, 100m, 165m and 478m depths. At 14m depth 69cm long silty clay core was collected by using short gravity corer. The core sample collected at 50m depth was 120cm of length with the texture of sandy nature. The grab samples were collected at 25m, 100m, 165m and 478m depths. The collected samples were processed and kept for further analysis. CTD and Zooplankton net were operated at 9°58'N, 75°35'E

**7<sup>th</sup> January, 2005:**

Station (off Kollam) arrived at 0735 hours, station location 8° 59.8'N, 76° 28.31' E. Core sample obtained was from 11.4 m depth, core length was 62 cm. At 27.1 m depth sediments sample collected using Grab sampler. At 50.3m water depth gravity corer and grab sampler were used. The bottom was sandy hence sample was obtained only in Grab corer. At 75 m, 104 m , 178 m and 312 m sample obtained was sand using the grab sampler. CTD and zooplankton net observations were carried out at 8° 52.84'N, 75° 56.57'E.

**8<sup>th</sup> January, 2005:**

Off Kanyakumari (8° 3.6'N, 77° 37'E) grab sampling was carried out at 17.5m depth. The sample obtained was sand. At 50 m, 100m and 200m Grab sample was used and the sample collected was sand. CTD was operated at 1500hours.

**9<sup>th</sup> January, 2005:**

CTD and zooplankton net were operated at 6°26.55'N, 78°6.48'E and at 5° 27.48'N, 78° 23.44'E. Two XBTs were launched at 6 hourly intervals.

**10<sup>th</sup> January, 2005:**

The vessel is heading to Nagapattnam . XBTs were launched at 6 hourly intervals.

**11<sup>th</sup> January, 2005:**

The vessel is heading to Nagapattnam. XBTs were launched at 6 hourly interval.

**12<sup>th</sup> January, 2005**

Arrived Nagapattinam (10° 44.8'N and 79° 56'E) at 1855hrs. Nagapattinam is the one of the most Tsunami affected area in the southeast coast of India. At 9 m depth short corer operations failed two times, hence Grab sampling was

carried out. The texture of the sediment was silty sand. The positions at 27.5m, 50m, 75m, 104.2m and 156.2m water depths Grab sampler and Zooplankton net were operated. All these depth the texture of the sediment was sand.

#### **13<sup>th</sup> January, 2005**

The locations at 191.4m (core) 251m and 290m (grab) water depths sediment sampling and Zooplankton net operations were operated (off Nagapattinam). The texture of the sediment obtained was sand. CTD operations were done at 10°44.7'N, 80°13.11'E and 10°45'N, 80°21'E. Reached off Cuadallore at 1655hrs. Short gravity corer was operated at 10.38m and 17m depth but no sediment was obtained. The positions at 10.38m, 25.3m, 65m, 71.5m, 94m (grab) and 186m (core) water depths sediment sampling and zooplankton net were operated.

#### **14<sup>th</sup> January, 2005**

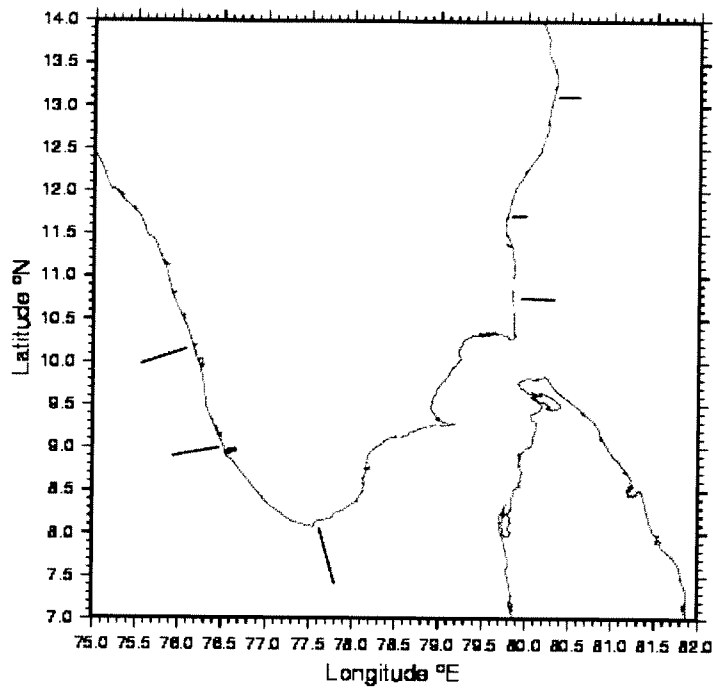
CTD and zooplankton net were operated at 11°43'N and 80°1.9'E. CTD was operated at 12°08'N, 80°17'E and 12°29'N, 80°40'E. At 17.30hrs CTD operated at 12°48.73'N, 80°52.22'E. At 2130hrs CTD operated at 13°6'N, 81°5'E. Core sample collected from 186 m depths. Length of the core was 96cm

#### **15<sup>th</sup> January, 2005**

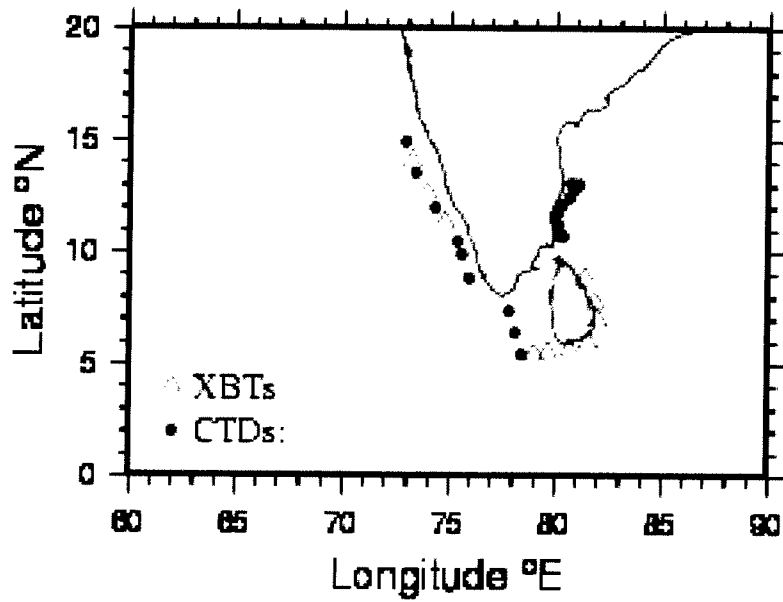
Off Chennai (13°6.84'N, 80°35.14' E) reached at 0225hrs. At 198.2m depth sediment collected by using grab sampler. Texture of sediment was silt. At 144m the sediment collected was silty clay. At 102.6m sediment collected was silty sand. At 47m sediment core (length 2.72m) collected was silty sand. At 24m and 14m the sediment collected was sand.

**Data Analysis and findings** : All CTD and XBT data have been processed, quality controlled and formatted following standard procedures. Vertical distribution maps of Temperature and Salinity and density are prepared for preliminary analysis.

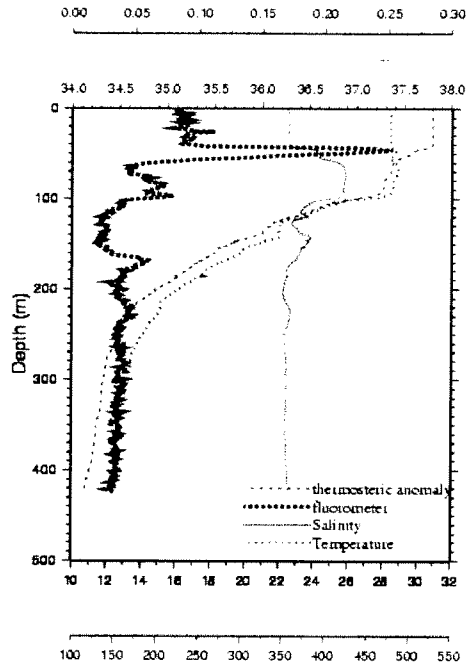
- Thermal section along Goa–Kochi shows warm waters (>28<sup>0</sup>C) occupying the upper 100 m water column (Fig. 3-11).
- However, from Kochi to west coast of Sri Lanka temperatures in the upper layers are cooler by 1<sup>0</sup>C ( ≈27<sup>0</sup>C) when compared with northern region (Fig. 3-5 &11).
- Salinity structure show a tongue of high salinity waters representing the presence of Arabian Sea High Salinity water Mass (ASHSWM) in the 50-110 m water column (Fig. 3-10 & 12).
- ASHSWM is present only between Goa and Kochi very clearly.



**Fig.1** — Geological sampling locations

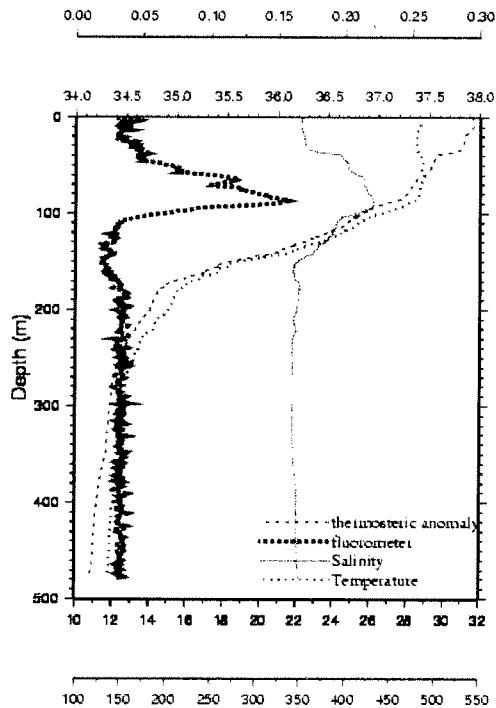


**Fig.2** XBT and CTD station locations

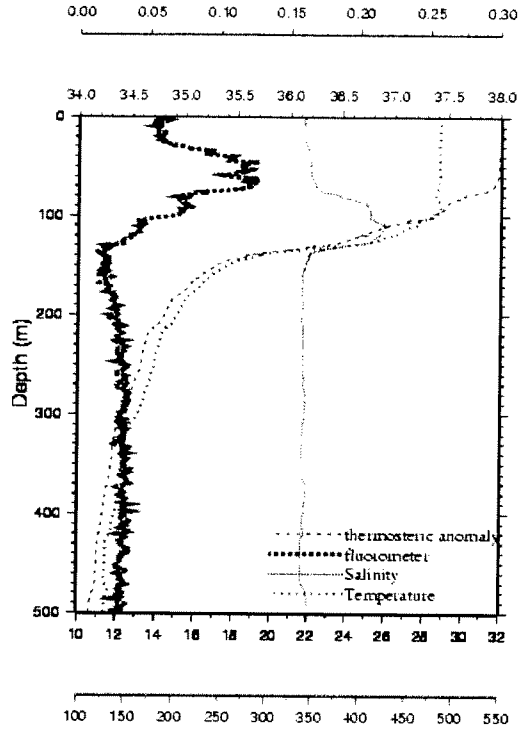


Scale: Temperature 10-32°C, Salinity 34-38‰, Fluorometer 0-0.3(Chelsea)  
 Thermocline anomaly 100-550 ( $10^{-3} \text{ m}^3 \text{ kg}^{-1}$ ), applicable to Figs. 3-10

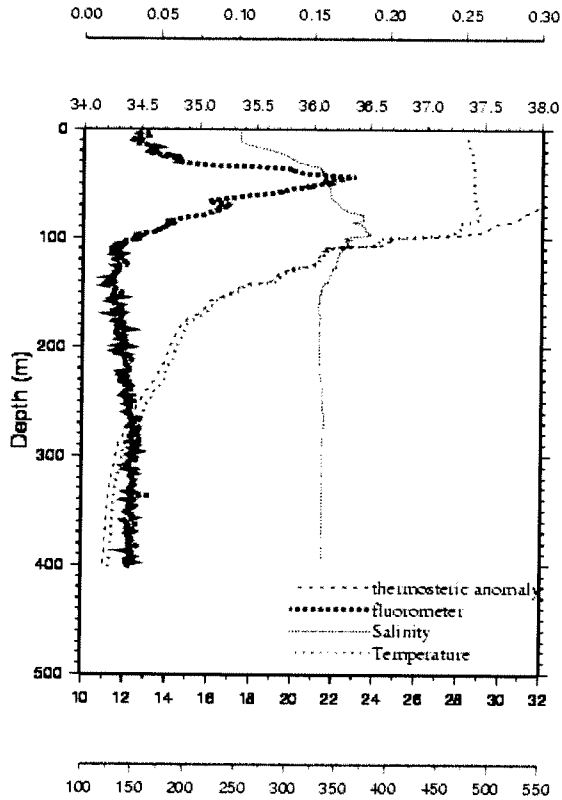
**Fig.3 Vertical profiles at CTD station -1**



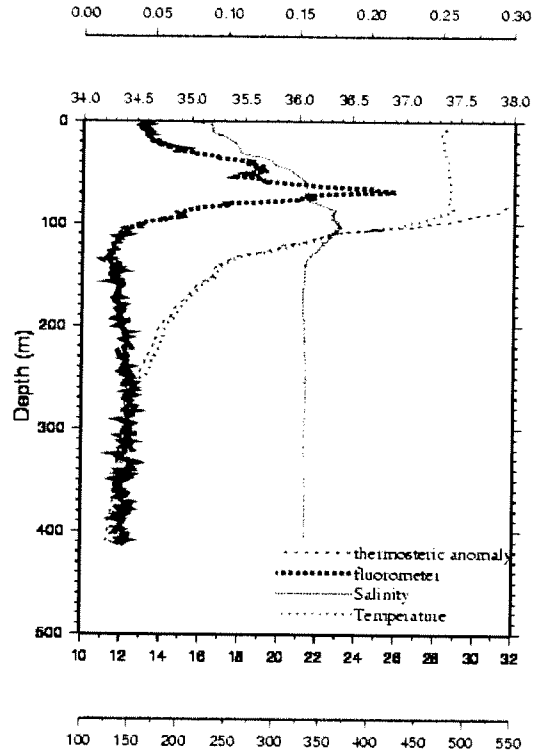
**Fig.4 Vertical profiles at CTD station -2**



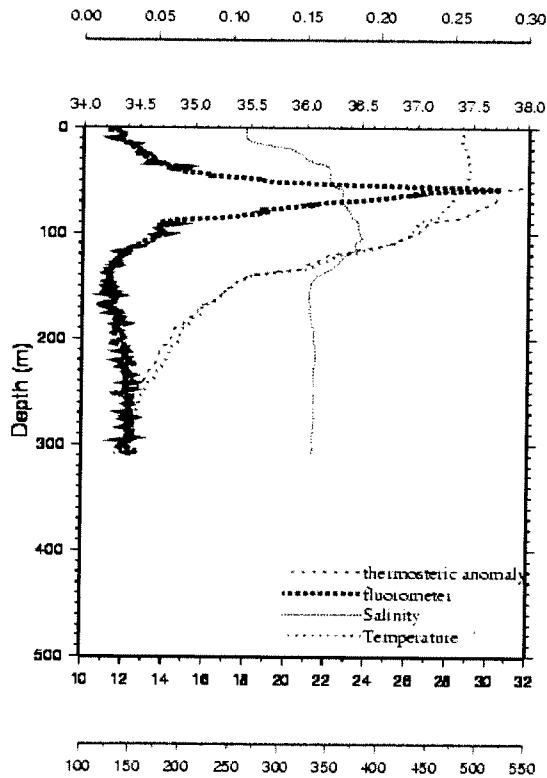
**Fig.5 Vertical profiles at CTD station -3**



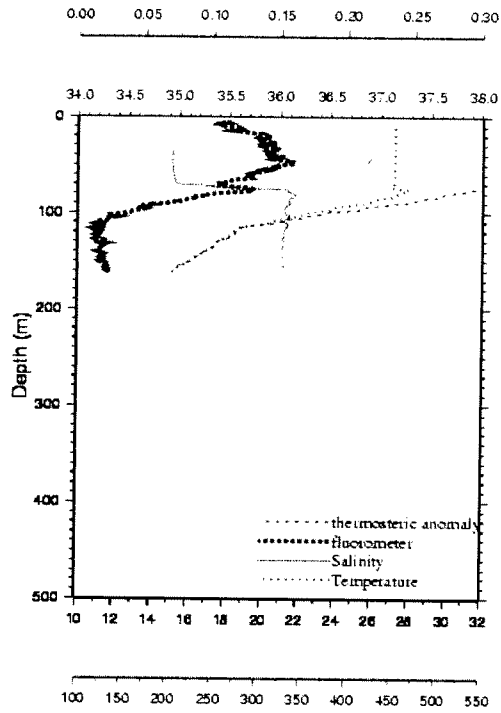
**Fig.6 Vertical profiles at CTD station - 4**



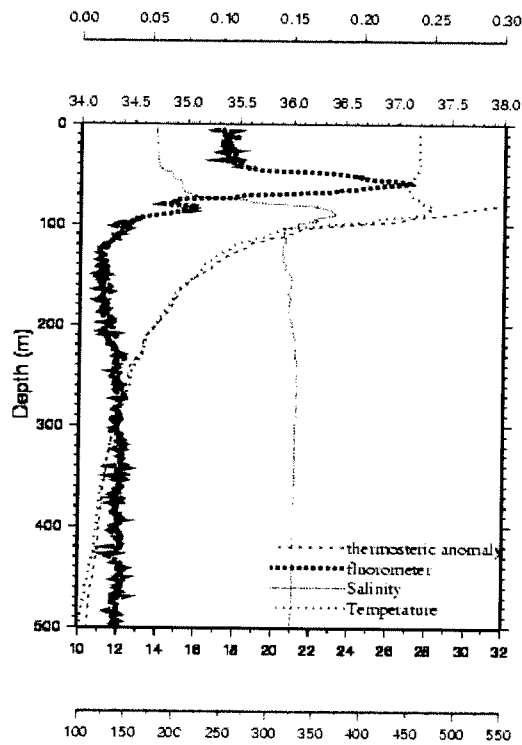
**Fig.7 Vertical profiles at CTD station -5**



**Fig.8 Vertical profiles at CTD station -6**



**Fig.9 Vertical profiles at CTD station -7**



**Fig.10 Vertical profiles at CTD station -8**



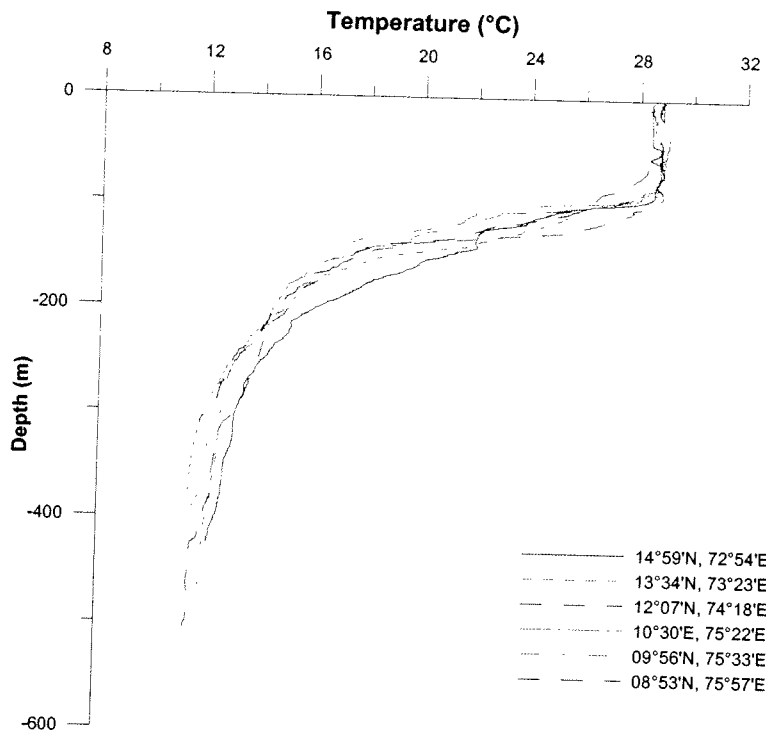


Fig- 11. Vertical structure of temperature (CTD)

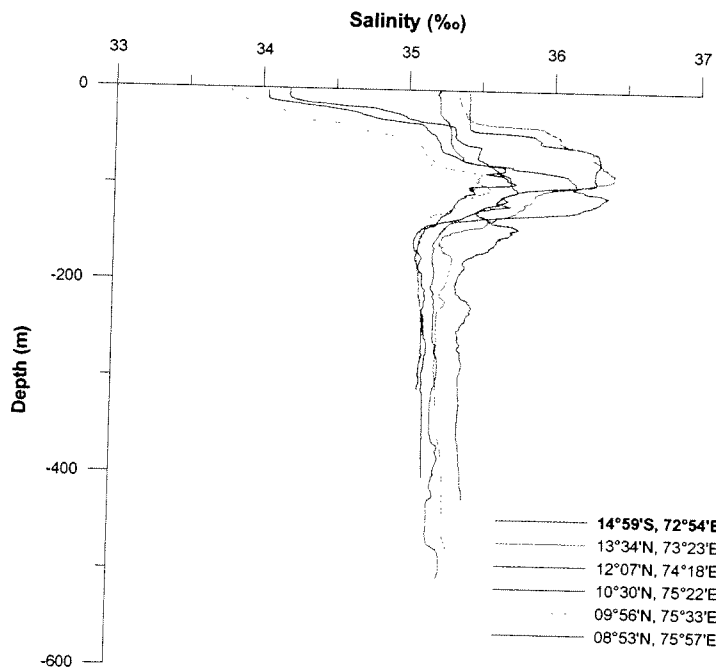


Fig-12. Vertical structure of salinity (CTD)

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