CRUISE REPORT

ORV SAGAR KANYA

Cruise No. 116

26 August to 17 September, 1996

राष्ट्रीय समुद्र विज्ञान
संस्थान

NATIONAL INSTITUTE
OF
OCEANOGRAPHY

ORV SAGAR KANYA

Cruise No. 116

(26 August to 17 September, 1996)

NATIONAL INSTITUTE OF OCEANOGRAPHY
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REPORT ON THE 116TH OCEANOGRAPHIC CRUISE OF ORV SAGAR KANYA

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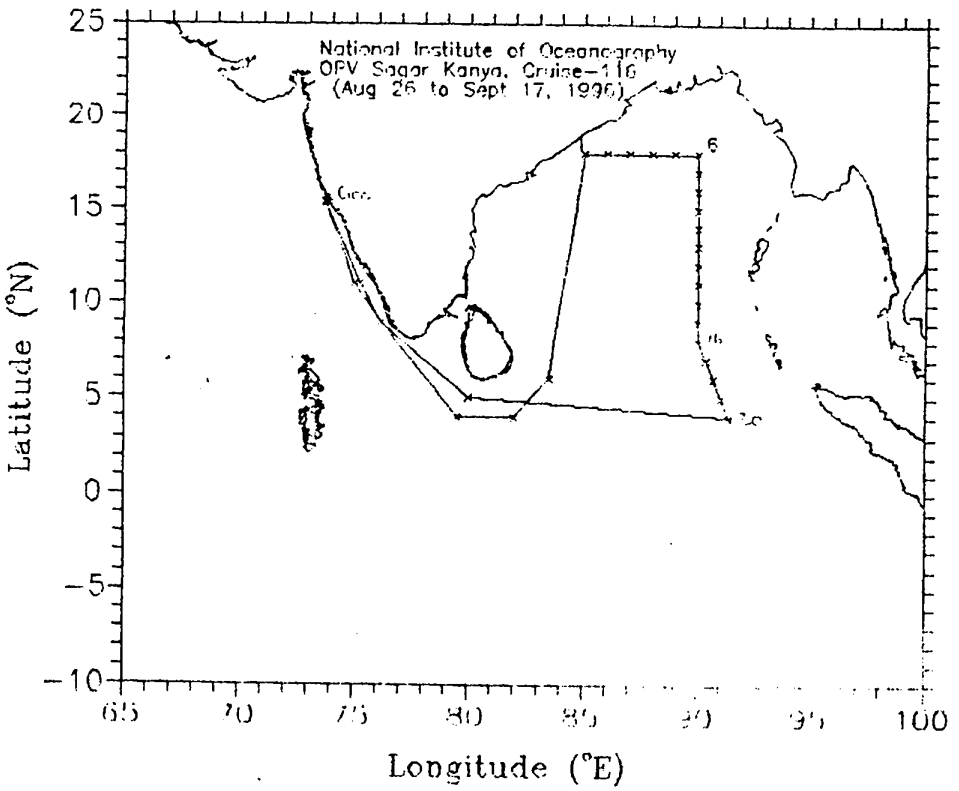
National Institute of Oceanography
ORV Sagar Kanya, Cruise-116
(Aug 26 to Sept 17, 1996)
Latitude (°N)
Longitude (°E)
25
20
15
10
5
0
-5
-10
65
70
75
80
85
90
95
100

2. CRUISE SUMMARY

ORV *Sagar Kanya* sailed out from Mormugao harbour on her 116th cruise on August 26, 1996 at 1700 IST with a total of 16 participants from various organizations. This cruise was organized to make repeat observations along 90°E which was earlier covered during monsoon and winter seasons of 1995. The objective was to document the seasonal and annual variability of thermohaline properties and circulation features in the eastern Indian Ocean.

During this cruise, physical and chemical oceanographic as well as radio sonde measurements of upper atmosphere were made. A total of 20 CTD stations were occupied along one zonal (18°N) and one meridional (90°E) section.

Water samples were collected from 10 CTD stations to study nutrients (nitrite and nitrate), Transparent Exopolymer Particles (TEP), dissolved oxygen, total alkalinity and pH. Nutrients were analyzed by Skalar auto analyzer and dissolved oxygen by spectrophotometric method using flow cell. Total alkalinity and pH were analyzed by high precision spectrophotometric method involving Bromocresol Green and Cresol Red respectively as indicators. TEP total concentration were measured colorometrically in terms of Alginic acid. All these analyses were completed on board. Apart from these, underway measurements of pCO_2 were done all along the cruise track from Mormugao and back.

During this cruise, 3 *METOCEAN* drifting buoys were deployed at pre-determined positions to study the large scale circulation features of the eastern Indian Ocean.

Weather during the cruise period was characterized by warm and clear sky conditions at the northern Bay while heavy rain fall events with strong winds were observed towards south of 13°N.

Cruise concluded on September 17, 1996 at Mormugao around 1200 IST.

3. PARTICIPANTS

3.1 Scientific component

Y.V.B. Sarma	—	Chief Scientist
G. Nampoothiri		
P.K. Saji	—	NIO, Goa
E.P. Rama Rao		
V.V.S.S. Sarma		
M.M. Subramaniam		
Lt. P.C. Dash	—	Indian Navy
A.K. Jaiswal		
D. Sarkar		
S. Benerjee		
V.A. Choudhary	—	India Meteorological Department
N.P. Mrutyunjaya		
R.P. Sharma		
Biju V. Nair		
K. Balakrishnan	—	NORINCO Pvt. Ltd., Vasco
K.M. Jayakrishnan		

3.2 Ship's Complement

Capt. R.M. Verma	—	Master
V. Subramanian	—	Chief Officer
S. Udayasurian	—	Second Officer
U. Gurayya	—	AWKO
Dr. S. Roy	—	Medical Officer
John M. Pinto	—	Radio Officer
R.G.S. D'Silva	—	Purser
S. Janaka	—	C/E/Officer
B. Singha	—	2/E/Officer
H.K. Jain	—	3/E/Officer
P.K. Ekka	—	3/E/Officer
S. Chakraborty	—	4/E/Officer
N. Tomar	—	5/E/Officer
A.S. Bhatia	—	EL/Officer
D.P. Sharma	—	EL/Officer
L.M.F. Rodrigues	—	Catering Officer

4. INTRODUCTION

4.1 General

The ship sailed on 26 August at 1700 hrs from Mormugao to study the inter-annual variability of physical characteristics along a transect in the Bay of Bengal and to study upper atmospheric conditions and chemical properties of the Bay along 18°N and 90°E sections. The ship arrived at the first hydrographic station at 18°N and 85°E on September 3, 1996.

The cruise was a part of the series of cruises conducted since 1995 under Indian component of WOCE programme.

4.2. Objectives

The Indian component of the WOCE (World Ocean Circulation Experiment) programme is being organized to quantify the seasonal and inter-annual variability of circulation and heat content in the eastern Indian Ocean along 9°E. The objective of the present cruise was to study the variability, primarily of the physical parameters, along 90°E between 4° and 18°N, during the southwest monsoon. This study intends to bring out information on the following:

1) Variability in the physical parameters like temperature, salinity, heat content and water mass structure of the eastern Bay of Bengal in response to the southwest monsoon forcing.
2) Variability of chemical parameters like dissolved oxygen, nutrients, alkalinity, pH and Transparent Exopolymer Particles (TEP).
3) Air-sea exchange of carbon dioxide.

4.3. Work Done

During the cruise two hydrographic sections were occupied covering a total of 20 CTD stations. Surface meteorological parameters were also measured at all the hydrographic stations. Thermosalinograph was operated continuously all along the cruise track to obtain the data on distribution of temperature and salinity at the sea surface.

The CTD probe (model SBE 11 plus, Sea Bird Electronics, Inc., USA) used for measuring pressure, temperature and conductivity has the following resolution and accuracy limits, Pressure: 0.001% and 0.15% of full scale, Temperature: 0.0002°C and 0.002°C and salinity: 0.0004 PSU and 0.003 PSU.

Water samples for salinity, oxygen and nutrient analyses were collected with a Rosette sampler fitted with 1.5 liter *General Oceanic* samplers and the above described CTD probe.

The water samples obtained from CTD operations were subjected to several chemical analyses. Nutrients studied were nitrite and nitrate. Gas analysis was done for carbon dioxide. The parameters studied to understand the carbon dioxide system included high precision spectrophotometric measurements of pH and alkalinity. Besides, the underway measurements of partial pressure of carbon dioxide were also performed in collaboration with the Woods Hole Oceanographic Institution, USA, and Transparent Exopolymer Particles (TEP) analyses were done at discrete depths. TEP studies include particle abundance, particle sizes and their total concentration in terms of alginic acid. All these analyses were completed on board.

While the vessel was on its way to the first station in the Bay of Bengal, a *METOCEAN* drifting buoy (ID: 11354) was deployed at 4°N/80.3°E, in the equatorial Indian Ocean. Further, two more *METOCEAN* drifting buoys were deployed, one on September 5 (ID: 11356) and the other on September 10 (ID: 11357) at 16°N/90°E and 4°N/91.2°E respectively to study the surface circulation patterns in the eastern Indian Ocean and the Bay of Bengal.

5. SALIENT FEATURES

The sea surface temperature (SST) varied between 28.93° and 29.60°C along 18°N while it varied between 28.13° and 29.07°C along 90°E. Sea surface salinity also exhibited wide variations with salinity lowering to 25.785 PSU at 18°N/87°E and increasing to 34.791 PSU at 8°N/90°E. Low salinity water along 18°N is associated with higher SST while the high salinity water in the south at 8°N is associated with lower SST. Another low surface salinity epoch occurred around 14°N along 90°E where the SST was higher. The large difference in the values of the two low salinity plumes suggests that their sources may be different. The mixed layer depth varied from 24 to 66 m along 18°N with shallow mixed layer coinciding with warm low saline water between 87° and 88°E where the thermocline too shoaled from 200 m at neighbouring stations to 177 m with an associated reduction in the upper layer heat content by 70 k.cal/cm^2. On the contrary, the warm low saline water around 14° has deepened the thermocline depth by about 20 m and resulted in the increase of upper layer heat content by 40 k.cal/cm^2. Along 90°E transect, the mixed layer depth varied between 52 and 92 m with deep mixed layer occurring at the southern end of the section.

Thermohaline structure depicted a plume of low salinity waters between 86° and 88°E along 18°N, presumably the fresh water discharged from the rivers at the northern end of the Bay, having a very shallow depth of penetration (about 5m). On either side of this low salinity plume, the surface salinity was about 32.2 PSU. Small cells of high salinity (35.2 PSU) identified earlier as remnants of Arabian Sea high salinity water mass was seen between 12° and 14°N and also between 6° and 8°N along 90°E around 100m depth.

The striking similarity in the distribution of temperature, salinity and light transmission (as an indicator of turbidity) in the upper 200 m water column along 18°N shows that below the surface mixed layer the thermohaline features appear to be governed by low frequency wave modes in the thermocline region.

The geostrophic currents computed relative to 1000 m depth along 18°N show strong southward flow between 85° and 87°E and northward flow across the rest of the section. This has given rise to a volume transport of 8.21x10^6 m^3/s towards south and 9.46x10^6 m^3/s towards north. The net volume transport across this section is 1.25x10^6 m^3/s towards south. Reversal of flow in the subsurface from being northerly at surface changing to southerly below 150m depth is also noticed along this section between 89° and 90°E. Across 90°E section, the flow pattern is dominated by westward current in the central Bay. However, alternating flows were observed at the northern and southern ends of the section between 18 - 15°N and 7 - 4°N with a regular spacing between such reversals. The net volume transport across 90°E section is 5.8x10^6 m^3/s towards west. Reversal of currents is noticed at subsurface depths at a few stations along this section. As a consequence, the integrated volume transport is found to be in opposite directions in the upper 100m and 100-1000m at stations where strong opposite flows exist at subsurface depth.

Across both the sections, the large fraction of volume transport occurred in the upper 100m.

The weather conditions during the cruise period were characterized by easterlies of around 5 m/s speed between 18 and 13°N. Towards further south, strong southwesterlies of around 10 m/s with speeds occasionally exceeding 15 m/s were observed. The skies were clear in the northern Bay but overcast towards south of 13°N. The rain fall recorded over oceanic region around 11°N on September 7 was as high as 57 mm.

Continuous underway measurement of carbon dioxide confirms that this gas is ejected into the atmosphere from the Bay of Bengal. However, from 17°N/84.30°E to 17°N/90°E, the surface pCO_2 values were well below the atmospheric concentrations (lowest equilibrated pCO_2 200 atm was observed) where the sea surface salinity varied between 25 and 32 PSU. This area appears to act as sink for atmospheric carbon dioxide whereas high equilibrated values of 520 atm (670 atm of surface pCO_2) were observed at 7.13°N/77.21°E where the sea surface was relatively cold and less saline (25.02°C and 34.97 PSU). This point is about 100 km away from the coast.

Total alkalinity values were lower in the north than in the south and ranged between 1850 and 2450 eq/l. TEP concentrations ranged between 20-100 mg/l in terms of alginic acid. Interestingly, their abundance was relatively higher at the base of the mixed layer and minimum (30-40 mg/l) in the subsurface layers around 400m.

Surface dissolved oxygen concentration was high in the northern Bay of Bengal. Whereas, oxygen concentration in subsurface layers was lower in the north than in the south. An oxygen minimum zone (1 M) was observed in the north of 16°N around 250 m depth. Along 18°N surface oxygen concentration increased towards east but this has not resulted in any significant change in its levels in the subsurface layers. Nitrate concentrations in the surface layers were well below the detection limits and no significant north-south gradient was observed either.

6. RECOMMENDATIONS

(i) It is highly desirable that a LAN of PCs and workstations together with output devices be established on board to provide adequate computing facility to the scientists of different faculties.

(ii) Standard meteorological sensors (wind vane, anemometer, thermometers, hygrometer, barometer, pyerheliometer, etc.) should be installed along with automatic data acquisition facility for continuous measurement.

(iii) On board E-mail facility should be established at the earliest to enable the scientists to reach NIO and other institutions while working at sea. This keeps the scientists abreast with the developments in the subjects of their research. This facility is also essential to gain information on the new literature being added to the NIO library as the cruises keep the scientists away from NIO library for long durations.

(iv) Chief Scientist's Cabin should have a PC connected to the LAN and a GPS display monitor.

7. ACKNOWLEDGEMENTS

Financial support was provided by the Department of Ocean Development, Government of India, for carrying out this oceanographic expedition. We appreciate the Master, officers and crew of ORV Sagar Kanya for their excellent cooperation that made the cruise pleasant and successful.

SK-116
Annexure-1

Details of observations carried out

Station #	Date	Latitude (°N)	Longitude (°E)	Time Arr. (IST)	Sonic Depth (m)	Operations CTD	Chemical obs.	Surface met. obs
WOCE01	03-09-96	18 00.00	85 00.00	0305	2400	y	y	y
WOCE02	03-09-96	18 00.00	86 00.00	0935	2400	y	-	y
WOCE03	03-09-96	18 00.00	87 00.00	1800	2450	y	y	y
WOCE04	04-09-96	18 00.00	88 00.00	0230	2200	y	-	y
WOCE05	04-09-96	18 00.00	89 00.00	1005	2150	y	y	y
WOCE06	04-09-96	18 00.00	90 00.00	1800	2100	y	y	y
WOCE07	05-09-96	17 00.00	90 00.00	0130	2350	y	-	y
WOCE08	05-09-96	16 00.00	90 00.00	1010	2550	y	y	y
WOCE09	05-09-96	15 00.00	90 00.00	1850	2700	y	-	y
WOCE10	06-09-96	14 00.00	90 00.00	0345	2830	y	y	y
WOCE11	06-09-96	13 00.00	90 00.00	1245	2950	y	-	y
WOCE12	06-09-96	12 00.00	90 00.00	2120	3100	y	y	y
WOCE13	07-09-96	11 00.00	90 00.00	0630	3200	y	-	y
WOCE14	07-09-96	10 00.00	90 00.00	1515	3290	y	y	y
WOCE15	08-09-96	09 00.00	90 00.00	0020	3100	y	-	y
WOCE16	08-09-96	08 00.00	90 00.00	0935	3240	y	y	y
WOCE17	08-09-96	07 00.00	90 20.00	1830	3500	y	-	y
WOCE18	09-09-96	06 00.00	90 40.00	0405	3650	y	y	y
WOCE19	09-09-96	05 00.00	91 00.00	1321	3700	y	-	y
WOCE20	09-09-96	04 00.00	91 20.00	2250	3800	y	-	y

y = Performed

Details of analyses carried out on water samples

Station #	Oxygen/ Nutrients	Gases	TEP	Salinity
WOCE01	y	y	y	y
WOCE02	-	-	-	y
WOCEO3	y	y	y	y
WOCE04	-	-	-	-
WOCE05	y	y	y	y
WOCE06	y	y	y	-
WOCE07	-	-	-	y
WOCE08	y	y	y	-
WOCE09	-	-	-	y
WOCE10	y	y	y	-
WOCE11	-	-	-	y
WOCE12	y	y	y	-
WOCE13	-	-	-	y
WOCE14	y	y	y	-
WOCE15	-	-	-	y
WOCE16	y	y	y	-
WOCE17	-	-	-	-
WOCE18	y	y	y	-

y = Analysed