CRUISE REPORT

ORV SAGAR KANYA

Cruise No. 103

(26 June to 15 July 1995)

राष्ट्रीय समुद्र विज्ञान संस्थान

NATIONAL INSTITUTE OF OCEANOGRAPHY

ORV SAGAR KANYA

Cruise No. 103

(26 June to 15 July 1995)

NATIONAL INSTITUTE OF OCEANOGRAPHY

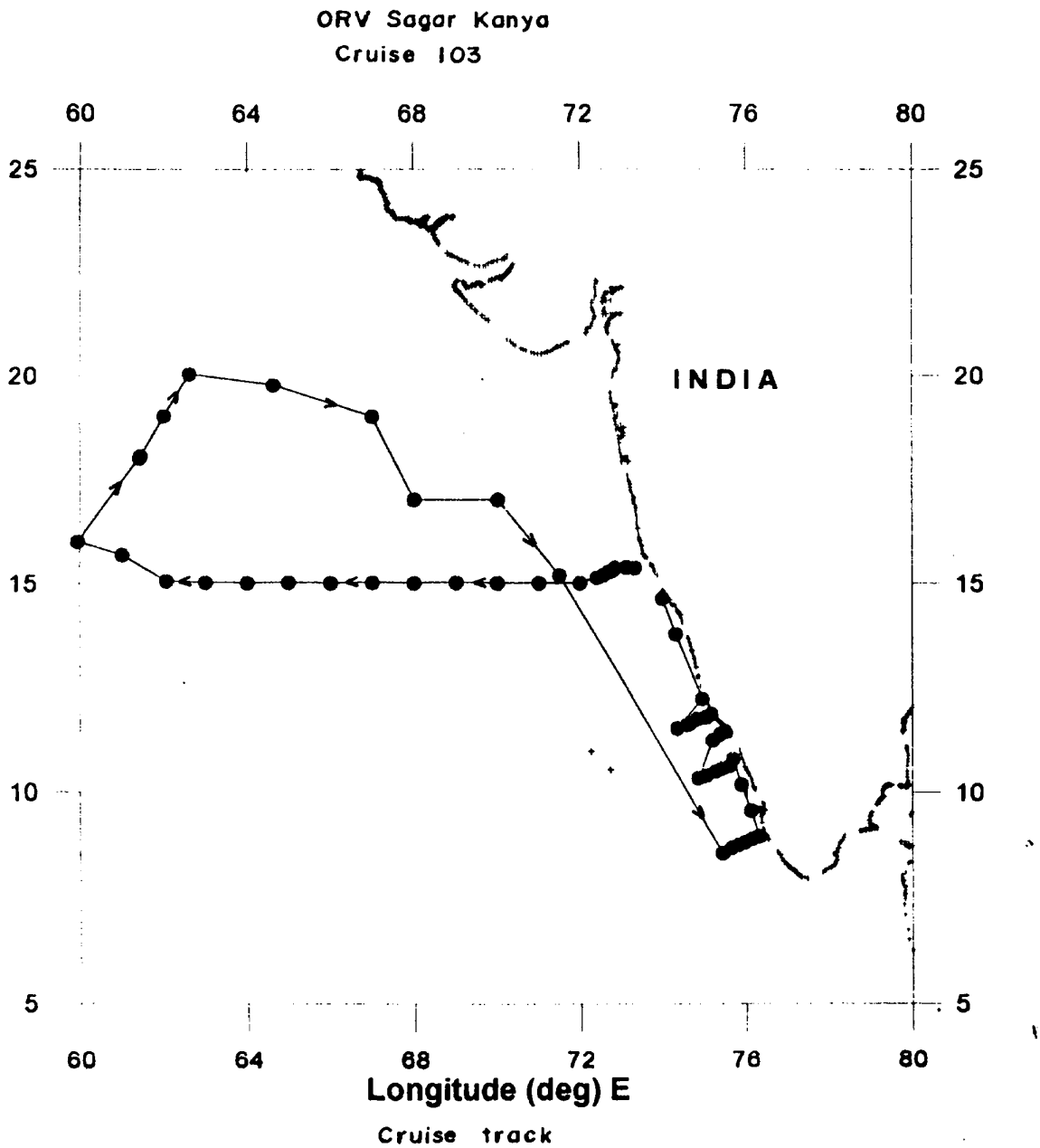
(Council of Scientific and Industrial Research)

Dona Paula - 403 004, GOA

Production : Scientist-In-Charge, Publication & Reprography Section
Editing : Rosy Thomas
Assistance : Arun Mahale, Basinda Ribeiro & Vijaya Duggal

REPORT ON 103rd OCEANOGRAPHIC CRUISE OF O.R.V. SAGAR KANYA

CONTENTS


ORV Sagar Kanya
Cruise 103
60
64
68
72
76
80
25
20
15
10
5
INDIA
Longitude (deg) E
Cruise track

2. Cruise Summary

The *Sagar Kanya* cruise no. 103 started from Mormugao port on 26 June 1995 and ended at the same port on 15 July 1995. The cruise had three major objectives: investigation of nitrogen transformations within the suboxic zone, estimation of air-sea CO_2 and N_2O fluxes and evaluation of the effects of coastal upwelling off the southwest Indian coast during the southwest monsoon. A total of 55 stations were occupied covering a large area. The highlight of the cruise was the observation of strong upwelling off the Kerala coast, manifested by high nutrient levels (nitrate up to 16 (μM) and extremely high pCO_2 and N_2O concentration (up to 700 μatm and 65 nM, respectively) at sea surface.

3.Participants

3.1 Scientific component

S.W.A. Naqvi, *Chief Scientist*	)
P.V. Narvekar	)
M.S. Shailaja	)
D.A. Jayakumar	)
M.M. Subramaniam	) NIO, Goa
Ravi Shankar	)
H.S. Dalvi	)
V.V.S.S. Sarma	)
Chanda Nasnolkar	)
Maheshwari Nair	) NIO, R.C. Kochi
Damodar M. Shenoi	)
Vanita D'Sousa	) Goa University, Goa
Varsha Kamat	)
Hema Naik	)

3.2 Ship's Compiement

Capt. Chidananda Pal	Master
M.S. Pangtey	Chief Officer
H.C. Medha	Addl. Chief Officer
M. Thangamani	W.N.O.
A.K. Tewari	A.W.K.O.
V.C. Chandran	Radio Officer
S. Murthy	Medical Officer
R. Saldanha	Purser
S. Gangopadhyay	C/Engr. Officer
P.K. Mitra	2/ Engr. Officer
R.P. Ghosh	3/ Engr. Officer
M.N. Muraleedharan	3/ Engr. Officer
D. Singh	4/ Engr. Officer
K.Prasad Mishra	5/ Engr. Officer
K. Pandey	Electrical Officer
P.J. Valson	Electrical Officer

4. Objectives

This cruise formed a part of the series of cruises undertaken during the past three years to investigate biogeochemical processes within the Arabian Sea suboxic zone. Apart from collecting hydrochemical and hydrographic data during the southwest monsoon to get a measure of seasonal and interannual changes, the process-oriented studies undertaken during the cruise were to address the following questions:

(a) What is the rate of denitrification in the Arabian Sea?

The Arabian Sea is one of the three major oceanic sites where an acute oxygen deficiency within a large body of intermediate waters causes large scale microbially-mediated reduction of nitrate ions to molecular nitrogen (denitrification). Appreciable seasonal changes in the denitrification regime had been previously reported. One of the main objectives of the cruise was to evaluate the extent of this seasonality.

(b) How and why is the nitrous oxide (N_2O) cycling in the Arabian Sea different from other oceanic areas?

Using ORV *Sagar Kanya* and FORV *Sagar Sampada*, we have also been gathering concomitant data on the dual isotopic composition and concentration of N_2O in the Arabian Sea. These have revealed a high degree of variability in its concentration within suboxic waters and enormous enrichment of the heavier isotopes (^{15}N and ^{18}O) associated with denitrification. Additional sampling was planned this time, especially in the upwelling region off Kerala, to provide insights into mechanisms of N_2O production in the ocean.

(c) What is the effect of seasonal upwelling off the southwest Indian coast on chemical composition of surface waters particularly in regard to climatically important gases [carbon dioxide (CO_2) and nitrous oxide (N_2O)]?

The work carried out previously demonstrated that although the Arabian Sea is a perennial source of CO_2 to the atmosphere, the air-sea fluxes of N_2O and CO_2 vary greatly with time. As previous samplings were confined largely to the non-monsoon months, the data collected during this cruise were expected to greatly improve estimates of overall fluxes of these gases from the Arabian Sea.

5. Cruise details

Observations were made at 55 stations as follows (Figure 1):

(a) Nineteen stations were occupied along a roughly zonal section off Goa. Although this section (Leg I) had been worked previously on a number of cruises, only one set of data had been collected during the crucial southwest monsoon period. Moreover, this time the section was extended farthest to the west (up to 63°N) in order to traverse the Findlater Jet.

(b) Five stations were occupied along a short transect oriented parallel to the Omani coast just outside its exclusive economic zone (EEZ) to investigate the effects of open ocean upwelling, if any, north of the Findlater Jet.

(c) Four stations were located within the suboxic zone of the northeastern Arabian Sea (17°N, 68°E; 17°N, 70°E; 19°N, 67°E and 19.75°N, 64.62°E). These stations are also occupied regularly during all cruises to monitor changes in redox conditions.

(d) Twenty six stations were worked along four shorter sections off SW Indian coast sampling across the continental margin. This was done to investigate the effect of coastal upwelling.

6. Sampling and On-board Analysis / Processing:

Water samples were collected at all the stations using 1.8, 5 and 20 litre Niskin/Go-flo bottles mounted on the CTD rosette. In addition to routine measurements of dissolved oxygen and nutrients, the on-board analyses also included pH, total carbon dioxide (TCO_2) and N_2O. Oxygen was estimated titrimetrically. A Skalar Autoanalyser was used for nutrients (nitrate, nitrite and phosphate). A spectrophotometric method was followed for precise pH measurements, and TCO_2 concentration was determined with the aid of a coulometer. A gas chromatograph was employed to analyse N_2O.

At 21 stations, water samples were taken (mostly from the surface) with modified 20-l Go-flo bottles. The dissolved N_2O was extracted with the aid of a specially designed extraction apparatus and adsorbed on MS 5A. Subsequently, N_2O was thermally desorbed in the shore laboratory, purified and analysed for determining its dual isotopic composition.

The highlight of the cruise was the novel incubation work using acetylene and isotopic tracers. At one station (#28) water sample was collected using 20-l Go-flo from the core of the denitrifying layer. About 10% of water in the sampler was replaced with acetylene-saturated water from the same depth without letting the sample to come in contact with the atmosphere. The sampler was kept in a cold room at near in-situ temperature for 8.7 hrs. A three-fold increase in dissolved N_2O was observed, demonstrating the feasibility of this technique for denitrification rate measurements. In other experiments, water samples from the denitrifying layer at three stations (#12, 26 and 27) were spiked with $^{15}NO_3$ and incubated in the same manner for 6.5-7 hrs following which N_2O was stripped from the samples and adsorbed on MS-5A for dual isotopic measurements.

Measurements of the activity of the respiratory electron transport system (ETS) and nitrate reductase activity were made at selected stations withinin oxygen deficient layer (170-300 m) to quantify respiration rates. Suspended particulate matter was collected at 8 stations in the southern leg for the analysis of organochlorine pesticide residues.

7. Significant Findings

Appreciable changes in hydrographical conditions as compared to the earlier observations were noticed. A noteworthy feature was the strong regulatory (inhibitory) effect of the Persian Gulf Water on denitrification, probably through supply of oxygen to the suboxic zone. Strong upwelling manifested by high nutrient levels (nitrate up to 16 µM) and extremely high pCO_2 and N_2O concentration (up to 700 µatm and 65 nM, respectively) at sea surface was found to occur off the Kerala coast. Incidentally, these were found to be among the highest recorded in the oceans. The high N_2O samples were isotopically the lightest (for N) found anywhere in the ocean, suggesting nitrification as a dominant formative mechanism.

8. Acknowledgement

The participants record their sincere thanks to the Master, officers and crew of ORV *Sagar Kanya* for their unreserved assistance without which the cruise would not have been a success.

ANNEXURE I

SUMMARY OF OBSERVATIONS

Ship: O.R.V. Sagar Kanya Cruise No. 103

Stn No.	Date	Time	Latitude N	Longitude E	Depth	CTD	Nutr & oxy	CO2	N2O	N2O iso	ETS	Incubation	Met obs
1	26/06/95	2350	15.368	73.311	65	x	x	xx					x
2	27/06/95	217	15.382	73.115	95	x	x	xx					x
3	27/06/95	519	15.372	72.832	210	x	x						
4	27/06/95	744	15.303	72.767	600	x	x						
5	27/06/95	1015	15.273	72.687	930	x	x	xx					x
6	27/06/95	1334	15.202	72.550	1400	x	x	xx					x
7	27/06/95	1657	15.140	72.405	1700	x	x	xx					x
8	27/06/95	2120	14.994	71.993	2000	x	x	xx					x
9	28/06/95	524	15.002	71.000	2600	x	x						x
10	28/06/95	1348	15.000	70.000	2600	x	x	xx					x
11	29/06/95	107	15.007	69.013	2600	x	x						x
12	29/06/95	1134	15.000	68.002		x	x	xx		x	x	x	x
13	30/06/95	801	15.005	67.005		x	x	x					x
14	30/06/95	1952	15.002	66.002		x	x	xx					x
15	01/07/95	704	15.011	64.992		x	x	xx			x		x
16	01/07/95	1940	15.002	64.007		x	x	xx					x
17	02/07/95	627	15.005	63.002	3900	x	x	xx		x			x
18	02/07/95	2127	15.050	62.066	3950	x	x	x	x				x
19	03/07/95	850	15.677	61.017			x	x	x	x			x
20	03/07/95	1930	16.001	59.957			x	x	x	x			x
21	04/07/95		18.055	61.448			x	x	x	x			x
22	04/07/95	1347	18.015	61.418		x	x	xx	xx	x			x
23	04/07/95	2214	19.009	62.009		x	x	x	x	x			x
24	05/07/95	651	20.026	62.613		x	x	xx	x	x			x
25	05/07/95	2013	19.752	64.622		x	x	xx					x
26	06/07/95	1332	19.000	67.000		x	x	xx	xx	x	x	x	x
27	07/07/95	902	17.000	68.009		x	x	xx	xx	x	x	x	x
28	08/07/95	128	16.994	70.017		x	x	xx	xx		x	xx	x
29	08/07/95	1915	15.185	71.503		x		xx		x			x
30	10/07/95	1632	8.581	75.433	1550	x	x	xx	xx	x			x
31	10/07/95	2323	8.700	75.632	300	x	x	xx	xx				x
32	10/07/95	2303	8.781	75.802	365	x	x	x	xx				x
33	11/07/95	144	8.841	75.963	310	x	x	x		x			x
34	11/07/95	429	8.928	76.141	55	x	x	xx	xx	x			x
35	11/07/95	624	8.986	76.319	40	x	x	x	xx	x			x
36	11/07/95	1044	9.580	76.114	25	x	x	xx	xx	x			x
37	11/07/95	1531	10.184	75.889	33	x	x	xx	xx	x			
38	11/07/95	2034	10.784	75.686	33	x	x	xx	xx	x			x
39	11/07/95	2251	10.632	75.604	33	x	x	xx	xx	x			x
40	12/07/95	103	10.568	75.418	110	x	x	xx	xx				x
41	12/07/95	300	10.500	75.250	260	x	x	xx	xx				x
42	12/07/95	532	10.399	75.035	1500	x	x	x	xx				x
43	12/07/95	832	10.335	74.851	2150	x	x	xx	x				x
44	12/07/95	1715	11.233	75.187	58	x	x	xx	xx				x
45	12/07/95	1930	11.364	75.370	40	x	x	xx	xx	x			x
46	12/07/95	2157	11.448	75.500	25	x	x	xx	xx	x			x
47	13/07/95	148	11.852	75.150	30	x	x	xx	xx	x			x
48	13/07/95	318	11.783	75.032	50	x	x	xx	xx				x
49	13/07/95	523	11.742	74.826	62	x	x	x	x				
50	13/07/95	738	11.634	74.651	620	x	x	x	x				x
51	13/07/95	904	11.601	74.873	750	x	x	x	x				x
52	13/07/95	1156	11.514	74.335	1750	x	x	x	x				x
53	13/07/95	1952	12.207	74.953	36	x	x	x	xx				x
54	14/07/95	726	13.770	74.307	36	x	x	xx	xx				x
55	14/07/95	1421	14.628	73.979	35	x	x	xx	xx				x

x - surface
xx- profile

x - incubation with N-isotope
xx - incubation with acetylene