

**REPORT ON 208TH OCEANOGRAPHIC CRUISE OF
O.R.V. SAGAR KANYA**

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1. Cruise Summary

The main objectives of the cruise were to investigate the causes and effects of seasonal suboxia along the west coast of India and to collect sediment cores for paleoclimatic/ paleoceanographic studies. The work undertaken comprised observations at a total of 30 stations including repeat samplings at three sites off Goa. These stations were mostly located along three transects of the shelf between Mangalore and Goa. In addition to the routine hydrographic (temperature and salinity) and hydrochemical (oxygen and nutrients) observations, specialised studies carried out during the cruise included measurements of dissolved gases (carbon dioxide, nitrous oxide, methane and dimethyl sulphide), biological parameters (bacterial production, chlorophyll, primary production and zooplankton), and the rates of benthic respiration (sedimentary denitrification and sulphate reduction). At one station a gravity core was raised for paleo-studies. As on previous cruises undertaken during the same season, the occurrence of intense suboxic conditions over the shelf was also observed on this cruise.

2. Participants

2.1. Scientific Complement

National Institute of Oceanography, Goa

Dr. S.W.A. Naqvi, Chief Scientist

Dr. P.V. Narvekar

Dr. M.S. Shailaja

Dr. D.M. Shenoy

Dr. Hema Naik

Dr. Mangesh Gauns

Shri Anand Methar

Mr. H.S. Dalvi

Dr. P.V. Bhaskar

Shri A.K. Pratihary

Shri B.R. Thorat

National Centre for Antarctic and Ocean Research, Goa

Shri K. Verma

Ms. Kamana Sahai
Shri V.S.K. Rao

Princeton University, NJ, USA

Dr. D.A. Jayakumar

NORINCO

Mr. Biju Nair
Mr. R.M. Ismail
Mr. P. Boopathy
Mr. P.J. George

2.2. Ship's Complement

Capt. M.D. Sanap, Master
Shri K. Pandian, Chief Officer
Shri B. C. Kalita, Second Officer
Shri P. P. Rawat, Third Officer
Shri James Jose, Medical Officer
Shri R. M. Horwood, Radio Officer
Shri M. Ali, Purser
Shri R. I. Chougule, Chief Engineer
Shri V. Muraleedharan, Second Engineer
Shri Varun Raina, Third Engineer
Shri T.N. Ulde, Fourth Engineer
Shri A.K. Singh, Fifth Engineer
Shri P.K. Patunnayil, Electrical Officer
Shri A.K. Chenal, Electrical Officer
Shri A.A. D' Silva, Catering Officer

Shri A. A. Silveira, Assistant Catering Officer

3. Cruise Schedule

The vessel sailed from Goa on 22 August and returned to Goa on 31 August, 2004.

4. Objectives

The major objectives of the cruise were:

- 4.1 *To investigate the effects of seasonal upwelling on biogeochemical cycling in the coastal zone off western India* – This formed a part of our ongoing monitoring programme (initiated in 1997) that focuses on the development of suboxic/anoxic conditions over the western continental shelf of India during late summer and autumn.
- 4.2. *To determine the rates of benthic respiration* – A large fraction of the organic matter produced during the productive upwelling season is degraded either within or close to the sediments, and yet the only data that are available on benthic respiration are based on just a few measurements of sedimentary denitrification made with the acetylene block technique. Incubation experiments were therefore planned to determine the rates of denitrification as well as sulphate reduction in shelf sediments.
- 4.3. *To characterize the microbial population involved with denitrification* – Very little is known about the microbes that are responsible for the key transformations within the nitrogen cycle (e.g. denitrification). This is because the majority of bacteria cannot be cultured and novel techniques such as gene sequencing need to be employed to gain insights into the diversity and functions of the bacterial population. The results of the work carried out during this cruise are expected to help better interpret chemical data.
- 4.4. *To utilize sedimentary records for reconstructing changes in oceanographic processes and climate during the late Quaternary* – Previous studies, undertaken mostly in the western Arabian Sea, showed that large changes in water circulation and biogeochemical cycling occurred in the past associated with both regional (monsoons) and global climatic oscillations. Hence sediment core sampling was planned focusing on the organic carbon enriched continental margin sediments of the eastern Arabian Sea where the paleo-signals are expected to be better preserved.

5. Sampling and On-board Analysis/Processing

All but one sampling stations were located along three cross-shelf sections off Mangalore, Karwar and Goa. The Goa transect is the time-series line also worked on numerous previous occasions; it was longest of the three sections, and extended beyond the continental margin. Geographical locations of these stations and a summary of various observations made/samples collected are given in the figure and tables.

CTD was deployed at all stations with the exception of the coring station off Karwar. At all CTD stations, chemical (oxygen, nutrients, nitrous oxide, carbon dioxide, pH and dimethyl sulphide) and biological (chlorophyll) measurements were made on a routine basis.

The recently acquired multiple plankton net (MPN) was operated at seventeen stations for stratified sampling of zooplankton.

Primary productivity was measured through day-long in situ incubations of samples spiked with ^{14}C at two stations - one each off Mangalore and Goa.

Bacterial production was measured at seventeen stations following the ^3H -thymidine method.

Spade corer was operated at eight stations - two off Mangalore, and three each off Karwar and Goa. Subcores were incubated on board for measurements of rates of denitrification (using isotope pairing technique at six stations) and sulphate reduction (using the ^{35}S method at eight stations) in sediments. Such measurements are the first of their kind to be made in Indian waters.

Gravity corer was operated at one station (located over a topographic high off Karwar at a water depth of 380 m) to collect a 4.5 m core, which was sub-sectioned for analysis in the shore laboratory.

On-deck experiments were conducted using waters from the shallow hypoxic zone to evaluate the importance of the anaerobic ammonia oxidation (ANNAMOX). Some samples were also filtered and preserved for the analysis of ANNAMOX biomarkers and also for characterizing the denitrifying bacteria through sequencing.

6. Significant Findings

The suboxic conditions were observed as expected. However, there appeared to be some difference in hydrographic regime this year from those observed on previous occasions. This was presumably related to a weaker stratification caused by the poor monsoon. For example,

at a shallow station off Goa, surface O₂ was as low as 18 µM with nitrate exceeding 15 µM, obviously caused the upwelling of water all the way to the surface. Such a phenomenon would adversely affect fisheries.

7. Performance of Equipment and General Recommendations

Most of the equipment used worked quite well throughout the cruise. The occasional problems (e.g. with the CTD unit toward the end of the cruise or with the Deep-Sea Winch) were fixed by the NORINCO personnel and ship's engineers. However, the multi-beam started giving error messages towards the end of the cruise.

The autoanalyzer is short of spares, especially the filters that should be procured urgently. The deep freezer in the Wet Starboard Lab is not very efficient, and it needs to be replaced. A new deep freezer capable of giving -80°C is strongly recommended for procurement.

Drainage system from the Chemical Lab and Wet Port Lab needs to be fully refurbished.

8. Losses

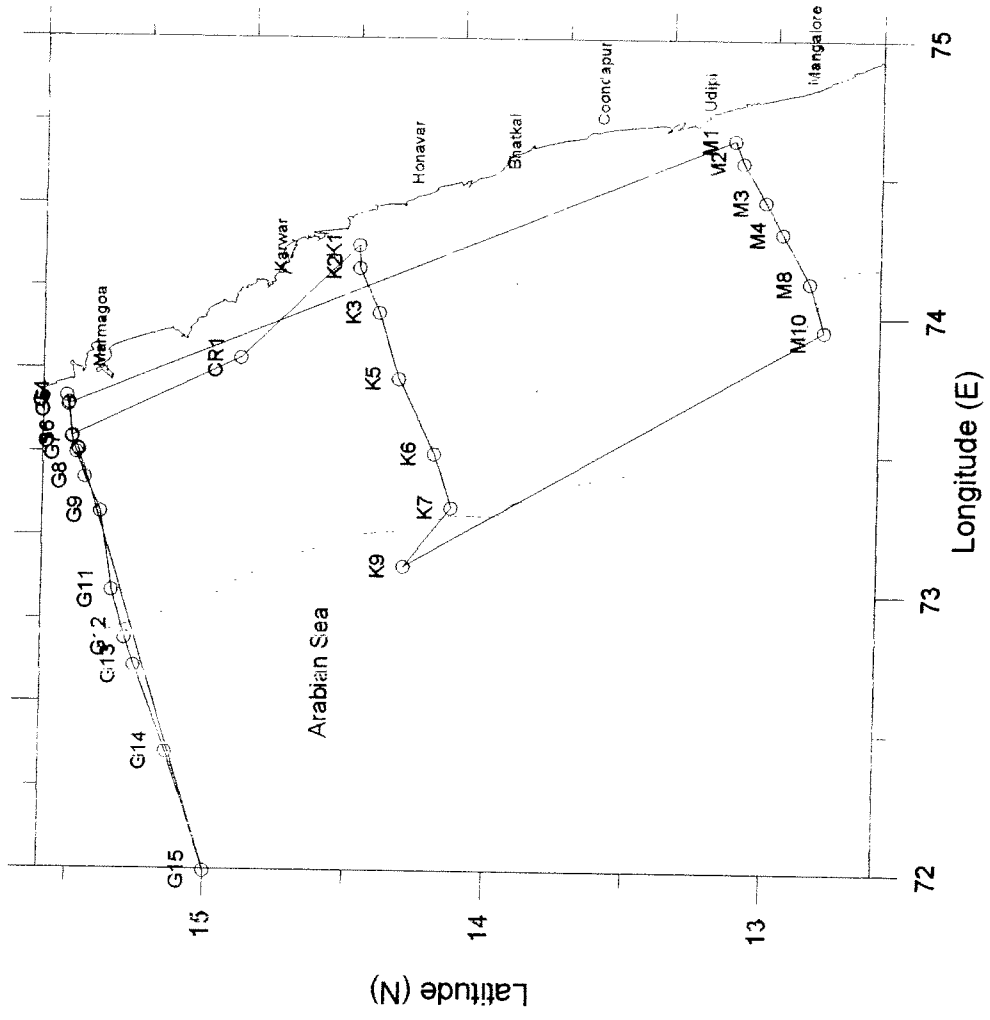
On 25th August, the CTD rosette hit the hull during retrieval, damaging four Niskin samplers.

9. Acknowledgement

The participants of SK 208 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

STA	LON	LAT	DO	N2O	CH4	TCO2	pH	DMS	NUT	PHYTO	CHL-A	N2/AR	PP	BACT	MPN	DNA	E	SPAD
G05	73.6680	15.5116	X	X	X	X	X	X	X	X	X	X	X	X				
M01	74.6383	13.1293	X	X	X	X	X	X	X	X	X	X	X	X	X			
M02	74.5563	13.0977	X	X	X	X	X	X	X	X	X	X	X	X	X			
M03	74.4163	13.0152	X	X	X	X	X	X	X	X	X	X	X	X	X			
M03A	74.6133	12.7080	X	X	X	X	X	X	X	X	X	X	X	X	X			
M04	74.3025	12.9533	X	X	X	X	X	X	X	X	X	X	X	X	X			
M08	74.1248	12.8535	X	X	X	X	X	X	X	X	X	X	X	X	X			
M10	73.9503	12.8015	X	X	X	X	X	X	X	X	X	X	X	X	X			
K09	73.0933	14.3000																
K07	73.3064	14.1310	X	X	X	X	X	X	X	X	X	X	X	X	X			X
K06	73.4990	14.1932	X	X	X	X	X	X	X	X	X	X	X	X	X			
K05	73.7682	14.3245	X	X	X	X	X	X	X	X	X	X	X	X	X			
K03	74.0071	14.3990	X	X	X	X	X	X	X	X	X	X	X	X	X			
K02	74.1683	14.4707	X	X	X	X	X	X	X	X	X	X	X	X	X			
K01	74.2500	14.4733	X	X	X	X	X	X	X	X	X	X	X	X	X			
CR1	73.8424	14.8916	X	X	X	X	X	X	X	X	X	X	X	X	X			X
G06	73.5510	15.4984	X	X	X	X	X	X	X	X	X	X	X	X	X			X
G04	73.7010	15.5180	X	X	X	X	X	X	X	X	X	X	X	X	X			
G05R1	73.6742	15.5087	X	X	X	X	X	X	X	X	X	X	X	X	X			
G06R1	73.5519	15.4968	X	X	X	X	X	X	X	X	X	X	X	X	X			
G07	73.4973	15.4789	X	X	X	X	X	X	X	X	X	X	X	X	X			
G08	73.4067	15.4492	X	X	X	X	X	X	X	X	X	X	X	X	X			
G09	73.2845	15.3908	X	X	X	X	X	X	X	X	X	X	X	X	X			
G11	73.0014	15.3468	X	X	X	X	X	X	X	X	X	X	X	X	X			
G12	72.8299	15.2965	X	X	X	X	X	X	X	X	X	X	X	X	X			
G13	72.7305	15.2617	X	X	X	X	X	X	X	X	X	X	X	X	X			
G14	72.4218	15.1437	X	X	X	X	X	X	X	X	X	X	X	X	X			
G15	71.9938	15.0000	X	X	X	X	X	X	X	X	X	X	X	X	X			



Cruise Track of ORV Sagar Kanya Cruise No. 208