Joint Oceanographic Projects
JOPS-II
Cruise Report and First Results

Sedimentation processes and Productivity in the Continental Shelf Waters off East and Northeast Brazil.

compiled by
Werner Ekau (ZMT) and Bastiaan Knoppers (UFF)

Center for Tropical Marine Ecology
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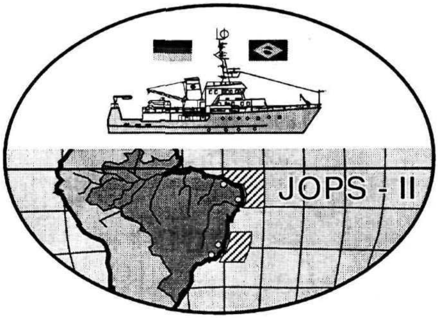

Sedimentation processes and Productivity in the Continental Shelf Waters off East and Northeast Brazil.

A multidisciplinary Research Programme with RV VICTOR HENSEN
within the Brazilian German Cooperation in Science and Technology

ZMT/BMBF - MCT/MMA

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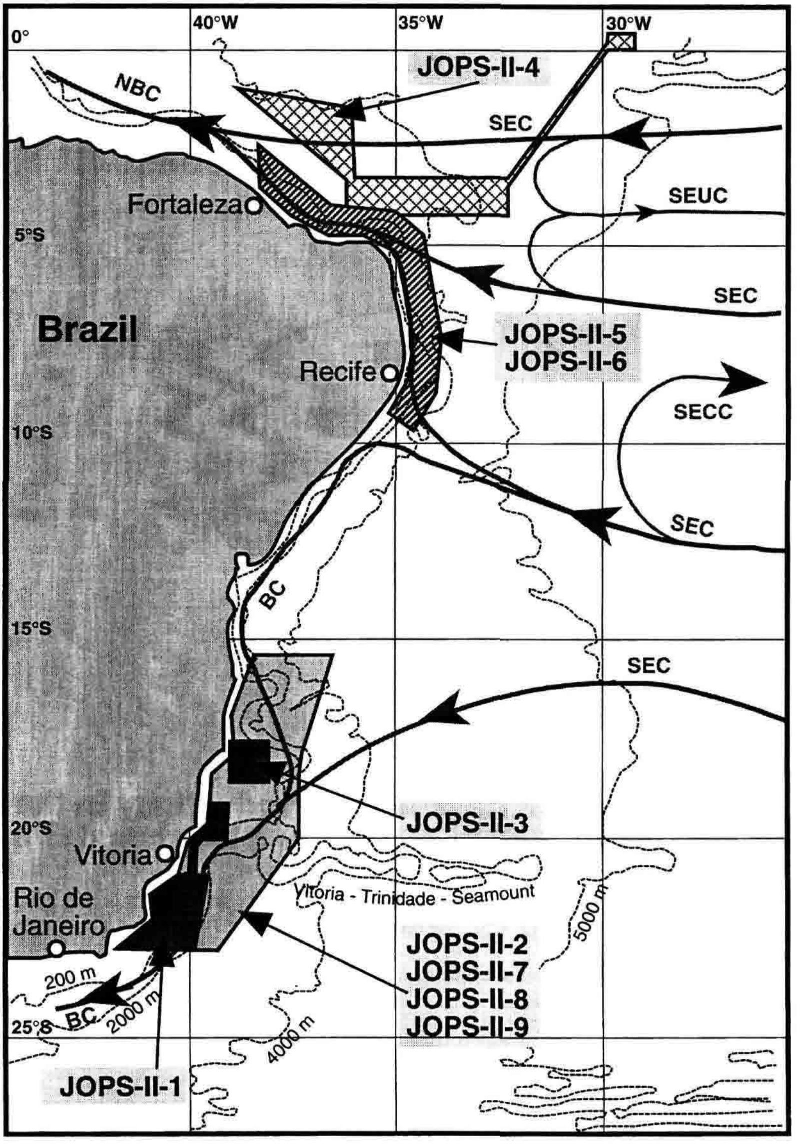

Area of investigation in Brazilian waters (hatched area) of RV "Victor Hensen" during the German-Brazilian cooperational programme JOPS-II from December 1994 to May 1995. The ports indicated on the map, were used for exchange of scientists and equipment. The current system is taken and modified from Stramma 1991.

Contents

1. Preface

The research cruise JOPS-II (Joint Oceanographic Projects) was carried out under the umbrella of the Brazilian-German agreement on the cooperation in science and technology established in 1969. In 1976 the cooperation was extended to the field of marine sciences. First activities have been courses and training of young scientists in different disciplines of marine research. Since the mid eighties, the interests focussed towards research projects. Small bilateral projects were executed with a balanced exchange of scientists. The number of projects and activities increased steadily during the last 10 years. Areas of interest within the cooperation cover all fields of marine research, e.g. Physical Oceanography, Biological Oceanography, Geosciences, Aquaculture, Biogeochemistry, Planktology and Benthology.

Outstanding events have been two cruises of the German Research Vessel "Victor Hensen", the first was realized in austral summer 1990/91. During five months, the ship collected samples and fundamental data on the structure and dynamics of the continental shelf and on the hydrography and production of the coastal waters between the Amazonas river in the north and Cape Santa Martha Grande in the south. Results were presented during a workshop in Niteroi in August 1993. The workshop was also the forum for extensive discussions on future activities and research fields within the cooperation and yielded a first proposal for a second "Victor Hensen" cruise in Brazilian waters, JOPS-II.

The results and discussions of the first JOPS-cruise cleary showed, that the second cruise had to focus on one general objective and that it would have to concentrate on one or two well defined areas of not only scientific interest, but particularly also of eonomic relevance. The idea was to create an interdisciplinary project to investigate the processes controlling the sedimentation and productivity in the eastern and northeastern continental shelf regions of Brazil, including the Abrolhos bank, plus the north-easterly offshore oceanic banks and islands. The objective and the concept of the cruise was accepted by the Brazilian Ministeries of Environment (MMA) and of Science and Technology (MCT), which participated in financing the charter costs for the ship. On the German side, an integrated project was created and financed by the Ministry of Science and Technology (BMFT, now BMBF), including the charter costs.

In comparison to the southeastern and northern coastal waters, information on the physical, chemical and biological processes in the chosen areas was less abundant. The economic interest in these areas is, however, increasing because of the manifold uses of the coast for settlement, tourism, forestry, agriculture and fisheries. The consequences of increasing eutrophication, terrigeneous input of heavy metals, other pollutants, suspended sediments and dissolved material had to be assessed, and will continue to be a main focal point for Brazilian coastal research in the future. The results of JOPS-II will also contribute to elucidate these topics which are also embedded in the now ongoing national Brazilian programme on the assessment of the living resources within the exclusive economic zone, REVIZEE.

The cruise started on 10 December 1994 in Rio de Janeiro, after the ship had returned from research work carried out in southern Chile. The expedition in Brazilian waters was divided into nine cruise legs, each of them with specific topics of investigation contributing to the general objectives:

Leg 1 and 3: Transport mechanisms of biogeneous material, heavy metals and organic pollutants in east Brazilian waters, leg 1 with a large scale design, leg 3 for small scale investigations.

Leg 2: Biogeochemical cycling of carbon, metals and phosphorus at the land-sea interface: role of mangroves and small rivers

Leg 4: Analysis of small scale patterns in distribution, productivity and dynamics of phyto-, microzoo- and macrozooplankton in the area of oceanic banks, islands and rocks off Northeast Brazil.

Leg 5: Influence of mangroves on diversity and productivity of the coastal waters of Northeast Brazil.

Leg 6: Geological and biological investigations on late Quaternary processes off Northeast Brazil.

Leg 7: Geophysical investigations of surface sediment structures in the Abrolhos region.

Leg 8: Paleo-oceanography and sedimentology in the Abrolhos region.

Leg 9: Diversity and distribution of ichthyoplankton in the continental shelf waters of east Brazil.

(Research areas of the different cruise legs are indicated in the map page 2)

The scientific programme ended on 8 May 1995 in Vitória, and RV Victor Hensen returned to Germany. On its way back, sediment trap moorings off the Rio Sao Francisco (lanced during leg 2) were recovered. After short calls in the ports of Recife, Cape Verde Islands and Canary Islands, the ship reached its home port Bremerhaven on 16 June 1995, after 288 days away from home, working 149 days at 656 stations in Brazilian waters and travelling a total of 33,500 miles, 15,259 of them along the Brazilian coast.

Aside preliminary technical cruise reports, first scientific results of JOPS-II were presented during an evaluation seminar for the German financier in Bremen in October 1995. In spite of the short time span after the end of the cruise, the seminar gave a good overview on the large amount of interesting data and preliminary results:

- The geophysical and geological studies (legs 6, 7 and 8) contributed to the reconstruction of sea-level history and the paleo-productivity of the Late Quaternary. The northeastern and eastern shelf, particularly also the paleo-lagoon of Abrolhos, were mapped by echosounding (18 Khz) and meso-scale sampling of surface sediments. The distribution of sediment types, compared with geological samples, was investigated as well as the correlation of characteristic reflexion patterns. A number of up to 5 m cores were taken for high resolution analysis of the stratigraphy and vertical distribution of chemical and biological constituents, including carbonates, organic matter, stable isotope signatures, and composition of foraminiferans. Comparisons between the cores obtained during JOPS II with those from earlier studies in adjacent deep sea areas showed a remarkable resemblance in the vertical resolution of stratigraphic and chemical features. The paleo-productivity results will also be linked to the findings on primary production and plankton composition from JOPS II and from earlier Brazilian studies. The information on the distribution of surface sediments were also of relevance for the studies on macrozoobenthos in defining the nature of the organisms substrate and subsequently distribution patterns.

- The mineralogical and biogeochemical studies (legs 2 and 6) revealed that the transport and deposition of terrestrial born material attains the shelf slope as far as 100 km from the coast. Sediment trap moorings over the slope off the Sao Francisco river showed that sedimentation rates are directly related to the seasonal input cycle of the fresh water source. The vertical partical flux is strongly influenced by the input of terrigeneous material from the river and causes high quantitative variability in sedimentation and accumulation of organic matter on the shelf edge. Free drifting sediment trap experiments in conjunction with analysis of surficial sediments (leg 1) revealed anthropogenic impact by poly aromatic hydrocarbons within the areas of the river plumes and also adjacent coastal waters of the eastern shelf, and analysis of suspended matter, sediment trap material, and surface sediments of the Abrolhos Archipelago indicated that the Paredes and Abrolhos reefs are partially being affected by deposition of land derived inorganic materials (leg 3).

- Nutrient and phytoplankton biomass concentrations, and rates of primary production were extremely low in both the coastal and oceanic waters of eastern and northeastern Brazil (legs 1,2,3,4,5, and 9). A trend towards heterotrophic metabolism was detected in all waters, particularly within the Abrolhos Banks.Grazing and faecal pellet production experiments performed with mesozooplankton showed that ingestion rates in the Sueste Channel near the coast were about threefold higher than in the Abrolhos Channel, whereas faeces production was nearly the same. Thus, total flux of organic matter mediated by zooplankton was similar in both areas.

- In the Northeast the highest biomass densities of zooplankton were found along the coast in front of mangrove-populated estuaries. High abundance of fish larvae were found in the surface hauls and in the integrating Bongo-hauls specially on the near-coast stations with a maximum distance of about 10 to 15 nm offshore. Oceanic stations showed lower biomass and low densities of fish larvae. The influence of seamounts upon plankton biomass was shown to be significant, but not yet well described by the data worked up until now (legs 4 and 5).

- Zooplankton and Ichtyoplankton density in the Abrolhos region was found to be significantly dependant on the hydrographical conditions. Mainly benthic and mesopelagic fish groups were present in the samples, an indication for the benthic-orientated system in this region. This is in strong contrast to the Southeast Brazilian coast (leg 9).

- Analysis of the benthic communities and biomass are still being undertaken by the Brazilian side (legs 4, 6 and 8).

Apart from the scientific value of the cruise, which allowed a considerable progress in the understanding of the sedimentation and productivity processes of the Northeast and East Brazilian waters, JOPS-II served as a focal point for bilateral and inter-institutional cooperation between and within both countries, Brazil and Germany. A total of 81 scientists from 22 institutes participated in the nine legs of the cruise.

Acknowledgements:

The JOPS-II-project was financed by the Ministries of Science and Technology of both countries (MCT and BMBF, former BMFT, project number 03F0144A) and the Brazilian Ministry for Environment (MMA and IBAMA). We would like to thank the ships agencies RF (Reedereigemeinschaft Forschungsschiffahrt, Bremen) and Lachmann Agencias Maritimas for their outstanding cooperation during the cruise and the port calls of the ship. The help of the Brazilian port authorities and the German consulates is also greatly acknowledged. Last but really not least our grateful thanks go to the crew members of "Victor Hensen", who always have been keen on making the impossible possible.

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2. Scientific Programme

Leg 1: Transport mechanisms of biogeneous material, heavy metals and organic pollutants in east Brazilian waters, large scale investigations

Chief Scientists: Prof. Dr. W. Balzer (UBMCH), Dr. B. Knoppers (UFF)

Cruise report

After the arrival of the formal permission to work in Brazilian coastal waters, RV VICTOR HENSEN left the harbour of Rio de Janeiro with 5 Brazilian and 3 German scientists and an observer of the Brazilian Navy on board. When arriving at the coastal zone in front of the Rio Paraiba do Sul the next morning the scientific study was started with a grid of water column stations to investigate the areal extent of the fresh water plume and its nutrient properties.

The aim of this study was to elucidate the transfer and fate of river borne matter (biogenic material, trace metals and organic pollutants) in the coastal zone of the Rio Paraiba do Sul and the Rio Doce, as examples of rivers with different anthropogenic impact.

1. Physical and chemical characterization of water column properties in the respective coastal plumes was performed by means of grid sampling. More than forty water column stations in the salinity range from 30 psu to 37 psu were occupied, aided by 12 additional samples from the Rio Paraiba do Sul between the fresh water and marine end members.

2. Drifting duplicate sediment traps were deployed to collect the large fast sinking particles in order to quantify the role of biogenic sedimentation for the cleansing of the water column from terrestrial pollutants. A total of 6 to 24 hour experiments with sediment traps were conducted, including 3 in the Rio Paraiba do Sul plume, 3 in the Rio Doce plume and 2 in coastal water free of major river impact. The deposition of terrestrial particles was surprisingly large, so that ample material could be collected for the desired parameter analyses.

3. Regular sampling of small suspended particles during the drift tracks of the sediment traps were obtained and used to analyse seston content, particulate organic carbon and nitrogen along with their isotopic signature, particulate organic phosphorus, pigments and particles by microscopical identificatlon. Analyses of particulate polyaromatic hydrocarbons (PAH) were restricted to trap material and sediments due to the low concentration. Sampling of at least two water depths per station yielded a total of 85 filter samples for each parameter. Simultaneously, large volume in situ pumps were employed 15 times to collect enough suspended material for the quantification of the usually low amounts of suspended trace elements. In the high turbidity zone of the plumes 52 filter samples of trace elements were obtained by regular filtration in a clean bench.

4. In order to investigate the ultimate fate of recently deposited material, 24 surface sediments were sampled from the river plumes and the adjacent coastal platform for analyses of the parameters mentioned above.

5. A separate study was devoted to the transformation and degradation of dissolved organic carbon (DOC). DOC samples were collected at all water column stations. In addition, three experiments were conducted to quantify the degradation rate of DOC under simulated in situ conditions.

6. To distingutsh between locally produced and allochthonous particles, the rate of primary production by the light simulating deck incubation C-14-method was measured eight times all over the investigated coastal zone.

After spending 5 days in the Rio Paraiba do Sul reglon, 4 days close to the Rio Doce and 2 days in the coastal zone outside the direct river impact, the RV VICTOR HENSEN arrived at the port of Vitoria on the 22.Dec.1994. In spite of adverse weather conditions during the first part of the cruise, all the planned scientific objectives were reached.

We particularly thank the crew of the RV VICTOR HENSEN for their constructive support of the scientific work and also the observer of the Brazilian Navy for his cooperation.

A complete list of stations sampled and the overall activities conducted during leg 1 of JOPS II is given in table1.

Tab. 1: List of stations sampled during leg 1 of JOPS II-2

Date/hour	Stat. No.	depth (m)	latitude	longitude	wind dir.	wind (bft)	OBS
12.12.1994							
10:00 Uhr	1	13	S 21°47,1	W 40°57,9	NNE	5	TS-FS
10:31 Uhr	2	14	S 21°48,0	W 40°56,1	NNE	5	TS-FS-WS
14:00 Uhr	3	11,8	S 21°48,2	W 40°59,0	NE	5	TS-FS-WS
16:00 Uhr	4	11,2	S 21°44,5	W 40°58,8	NE	5	TS-FS-WS
17:00 Uhr	5	12,8	S 21°40,5	W 40°58,2	NE	4	TS-FS-WS-LS
19:00 Uhr	6	11	S 21°36,7	W 40°58,8	NE	5	TS-FS-WS
20:00 Uhr	7	9	S 21°33,5	W 40°00,4	NE	5	TS-WS-FS
21:00 Uhr	8	10	S 21°29,6	W 40°58,9	NE	5	TS-FS-WS
13.12.1994							
9:50 Uhr	9	11	S 21°48,4	W 40°58,9	NE	5/6	TS-WS-LS-BG
11:00 Uhr	10	11	S 21°44,5	W 40°58,7	NE	5/6	BG
12:00 Uhr	11	12	S 21°40,6	W 40°58,2	NE	5/6	BG-TS
13:00 Uhr	12	12	S 21°36,6	W 40°58,8	NE	5/6	BG-TS
13:50 Uhr	13	10	S 21°33,6	W 41°00,4	NE	5/6	BG-TS
14:35 Uhr	14	10	S 21°29,6	W 40°58,9	NE	5/6	BG-TS
18:00 Uhr	15	26	S 21°30,1	W 40°32,9	NE	5/6	TS-FS-WS-Pp-BG
21:45 Uhr	16	20	S 21°31,8	W 40°43,8	NE	5	TS-WS-FS-Pp
14.12.1994							
10:50 Uhr	17	16	S 21°37,0	W 40°57,8	NE	4/5	STr
11:05 Uhr	18	16	S 21°37,0	W 40°57,8	NE	4/5	TS-WS-FS-BG
14:10 Uhr	19	14,5	S 21°38,5	W 40°57,5	NE	5	TS-FS-Pp-BG
18:00 Uhr	20	11	S 21°41,8	W 40°58,0	NE	6	TS-WS-FS
15.12.1994							
6:00 Uhr	21	12	S 21°49,1	W 40°57,6	NNE	5	TS-FS-WS
9:40 Uhr	22	10	S 21°33,8	W 40°59,3	NNE	5	STr
11:30 Uhr	23	11	S 21°36,7	W 40°59,0	NE	4/5	TS-WS-FS-LS-BG
13:45 Uhr	24	11	S 21°35,0	W 40°59,9	NE	4/5	TS-FS-Pp-WP
18:25 Uhr	25	12	S 21°37,0	W 40°58,7	VAR	4	STr
19:15 Uhr	26	14	S 21°37,6	W 40°58,6	NE	3/4	TS-FS-WS-Pp
16.12.1994							
8:15 Uhr	27	12	S 21°40,5	W 40°57,9	VAR	1	TS-FS-WS-LS-Pp
9:40 Uhr	28	12	S 21°40,5	W 40°57,9	VAR	1	Pp
17.12.1994							
0:50 Uhr	29	1200	S 20°00,0	W 39°36,0	NE	5/6	TS-FS-WS-Pp
8:40 Uhr	30	9	S 19°39,4	W 39°47,3	NE	5/6	TS-FS
9:15 Uhr	31	11	S 19°39,9	W 39°47,3	NE	5/6	STr
11:00 Uhr	32	12	S 19°40,3	W 39°47,2	NE	5	FS-TS-WS-LS-BG-Pp
18:10 Uhr	33	18	S 19°43,8	W 39°49,0	NNE	5	STr-Pp
18:20 Uhr	34	18	S 19°43,9	W 39°49,0	NNE	5	TS-WS-FS
20:00 Uhr	35	19	S 19°43,9	W 39°48,1	NNE	5	Pp

Tab. 1 continued

Date/hour	Stat. No.	depth (m)	latitude	longitude	wind dir.	wind (bft)	OBS
18.12.1994							
10:50 Uhr	36	13	S 19°38,4	W 39°48,1	N	4	BG
11:15 Uhr	37	10	S 19°39,4	W 39°45,4	N	3	STr
12:00 Uhr	38	11	S 19°41,5	W 39°48,3	NNE	5	TS-WS-FS
17:15 Uhr	39	19	S 19°41,3	W 39°47,5	NE	6	STr
18:10 Uhr	40	19	S 19°42,9	W 39°47,8	NNE	4/5	TS-FS-WS
19.12.1994							
8:10 Uhr	41	32	S 19°48,1	W 39°49,7	SE	2/3	STr-TS-FS-WS
11:00 Uhr	42	12	S 19°30,2	W 39°41,9	SE	2/3	BG
11:28 Uhr	43	13	S 19°32,4	W 39°43,0	SE	2/3	BG
11:46 Uhr	44	13	S 19°34,4	W 39°44,0	SE	2/3	BG
12:12 Uhr	45	12	S 19°36,3	W 39°45,0	SE	2/3	BG
13:25 Uhr	46	14	S 19°41,7	W 39°51,5	SE	2/3	BG
13:45 Uhr	47	15,5	S 19°42,4	W 39°51,5	S	3	BG
14:08 Uhr	48	17,5	S 19°43,4	W 39°55,0	S	3	BG
14:28 Uhr	49	16,5	S 19°44,5	W 39°56,8	S	3	BG
14:44 Uhr	50	16,5	S 19°45,8	W 39°58,3	S	3	BG
14:55 Uhr	51	18,5	S 19°46,2	W 39°57,9	S	3	STr-TS-FS-WS
20.12.1994							
10:05 Uhr	52	15	S 19°49,3	W 40°01,3	VAR	1	TS-FS-WS-LS
13:20 Uhr	53	26	S 19°51,5	W 40°58,4	SE	2/3	TS-WS
21.12.1994							
9:10 Uhr	54	20	S 19°47,6	W 39°57,9	VAR	1	TS-FS-WS
13:05 Uhr	55	17	S 19°45,5	W 39°56,7	VAR	1	STr
14:00 Uhr	56	16	S 19°51,0	W 40°02,2	VAR	1	BG
14:50 Uhr	57	13	S 19°56,6	W 40°05,9	E	2/3	BG
15:50 Uhr	58	15,5	S 20°05,7	W 40°09,3	E	2/3	BG

OBS Legend: TS (Temp.-Salinity) FS (Fluorescense) WS (Water Sampling)
LS (Light Sampling) STr (Sediment Trap) BG (Bottom Grab)
Pp (In-situ-Pump)

First results

I. Nutrients and suspended matter

B.Knoppers (UFF), M.E.Carneiro (UFF), U.M.Mendoza (UFF) & W.Balzer (UBMCh)

Within the cruise report (leg. 1) the numbers, the geographical location, depth, prevailing wind conditions, and the activities at the stations are compiled. Figures 1a and 1b depict the 8 sediment trap drift tracks and the corresponding locations at the stations sampled. Except for one experiment, all sediment traps drifted in a North-South direction more or less parallel to the coast, mainly due to the prevailance of NE winds. The sediment traps were directly deployed below the moderate haloclines, which seperated the homogeneous surface waters of the river plumes and the homogeneous bottom waters of the coast. Horizontal and vertical salinity gradients between the rivers mouths and the coastal waters from the 10 m isobath onwards ranged between 30 and 37 ppt. Below the Rio doce turbid plume, waters from deeper oceanic layers (South Atlantic Central Water) were detected, indicating the presence of wind and bottom topography driven Upwelling. It is assumed, that in some experiments, the resuspension of bottom material must have played an important role in the recorded sedimentation rates. In all experiments, sedimentation rates were high and enough sedimented material was collected for parameter analyses.

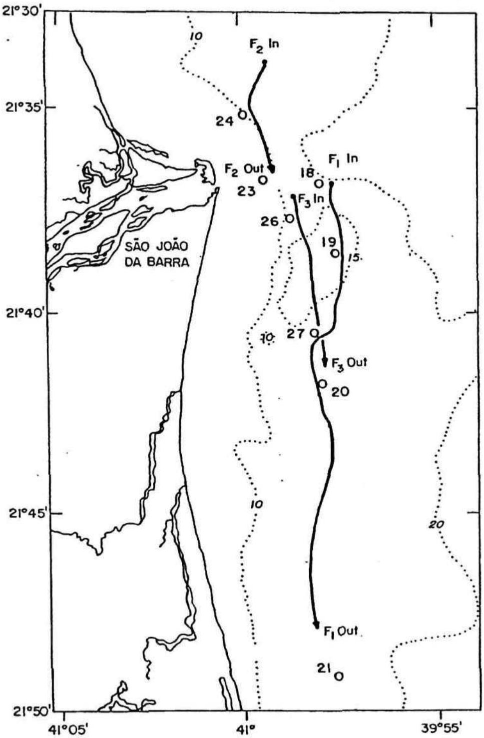

Fig. 1a: Sediment trap drift tracks off the Paraíba do Sul river mouth, coast of Rio de Janeiro state. Sampling station are indicated by circles

Tables 1 to 3 presents the results of dissolved inorganic nutrients, phosphorous species, Seston Dry Weight, and chlorophyll a. In all, nutrient concentrations were low, except for some medium levels of amonia which coincided with the results obtained in JOPSII-Leg 2 in the same region. Higher Seston DW concentrations were encountered within the plumes and lower in the adjacent coastal waters, and at some nearshore stations surface and bottom concentrations were similar in spite of vertical water column stratification. This suggests, the presence of resuspension of bottom material generated by the proliferation of coastal bottom waters.

In order to obtain information on the fresh water end member, a transect with 11 surface stations (St. A to K, tab.2) from the Rio Paraiba do Sul river outwards along the plume was conducted. All parameters showed non-conservative behaviour in relation to salinity, and highest concentrations within the freshwaters, particularly the nutrients. Particulate organic phosphorous represented the largest phosphorous fraction, and the dissolved inorganic and organic fractions presented similar levels.

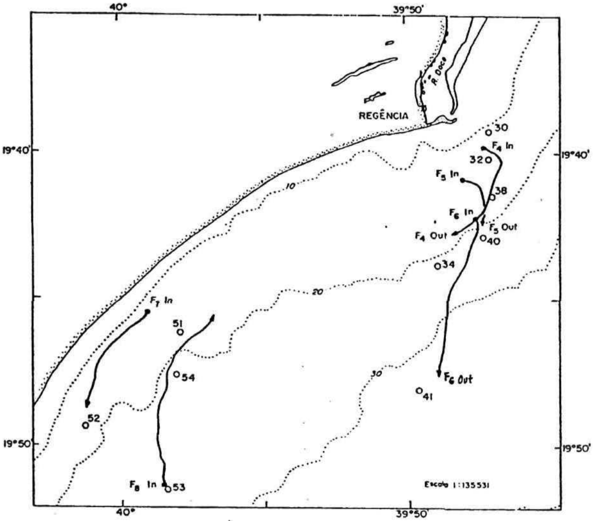

Fig. 1b: Sediment trap drift tracks off the Doce river mouth and in adjacent coastal waters, coast of Espirito Santo state. Sampling stations are indicated by circles.

Tab. 1: Doce Plume

Station #	Depth (m)	NH4-N (µm)	NO2-N (µm)	NO3-N (µm)	NIT-N (µm)	PO4-P (µm)	POD (µm)	POP (µm)	N:P (µm)	SESTON (mg/dm3)	Chl.a (µg/dm3)
17. Dezember 1994											
#29	10,0	3,54	0,10	-	-	0,07	0,06	0,00	-	23,10	0,009
#32	2,0	2,13	0,11	-	-	0,12	0,31	0,50	-	20,50	2,07
	7,0	1,77	0,11	0,11	1,99	0,17	0,16	0,20	11,70	11,00	0,98
#34	2,0	1,82	0,15	-	-	-	-	0,20	-	12,20	0,84
	7,0	1,98	0,13	0,36	2,47	0,23	0,08	0,20	10,70	10,20	0,83
18. Dezember 1994											
#38	1,0	1,77	0,15	0,28	2,20	0,21	0,10	0,40	10,50	17,90	2,85
	7,0	2,55	0,23	0,74	3,52	0,25	0,12	0,50	14,10	18,50	1,27
#40	2,0	2,03	0,17	1,25	3,45	0,24	0,11	0,17	14,40	12,40	0,66
	15,0	2,34	0,13	1,05	3,52	0,23	1,21	0,20	15,30	24,30	0,59
19. Dezember 1994											
#41	2,0	2,18	0,15	0,97	2,83	0,18	0,04	0,11	15,70	9,50	0,43
	7,0	2,18	0,17	0,48	2,83	0,23	0,03	0,14	12,30	12,80	0,57
#51	2,0	2,08	0,11	0,42	2,61	0,21	0,05	0,14	12,40	4,60	0,95
	7,0	2,44	0,19	0,48	3,11	0,17	0,14	0,13	18,30	5,20	0,69
	15,0	2,44	0,19	0,99	3,62	0,22	0,08	0,11	16,50	6,00	0,50
20. Dezember 1994											
#52	2,0	2,18	0,06	0,53	2,77	0,15	0,10	0,13	18,50	4,80	0,47
	7,0	2,05	0,04	0,46	2,55	0,15	0,07	0,13	17,00	4,90	1,25
	12,0	2,64	0,10	0,76	3,50	0,23	0,09	0,11	15,20	15,00	-
#53	2,0	2,31	0,04	0,94	3,29	0,15	0,08	0,13	21,90	4,40	0,61
	7,0	2,51	0,08	-	-	0,18	0,05	0,10	-	4,60	0,61
#54	2,0	1,39	0,04	-	-	0,15	0,12	0,08	-	8,40	0,26
	7,0	1,25	0,02	0,60	1,87	0,09	0,10	0,08	20,80	0,30	0,33
	13,0	1,65	0,02	0,60	2,27	0,19	0,12	0,15	12,00	3,90	0,23

Tab. 2: Paraíba do Sul River

Station #	Depth (m)	NH4-N (µm)	NO2-N (µm)	NO3-N (µm)	NIT-N (µm)	PO4-P (µm)	POD (µm)	POP (µm)	N:P (µm)	SESTON (mg/dm3)	Chl.a (µg/dm3)
A	1	2,30	0,36	36,70	39,60	0,23	0,27	1,10	172	24,50	2,99
B	1	2,66	0,34	41,00	44,20	0,21	0,25	1,30	210	44,10	3,96
C	1	2,48	0,32	44,90	47,90	0,21	0,11	1,30	225	18,40	2,80
D	1	2,12	0,34	45,10	47,70	0,23	0,14	1,20	207	32,00	3,33
E	1	2,18	0,32	50,60	53,30	0,23	0,10	1,00	231	29,20	55,00
F	1	1,77	0,28	47,90	50,10	0,26	0,20	1,50	193	18,80	11,27
G	1	2,01	0,32	6,95	9,42	0,23	0,22	0,90	41	15,60	3,66
H	1	1,77	0,12	3,54	5,48	0,08	0,08	0,30	69	49,00	1,69
I	1	1,59	0,16	1,54	3,36	0,05	0,10	0,20	67	44,30	1,19
J	1	1,53	0,12	1,62	3,30	0,07	0,07	0,14	47	33,50	0,74
K	1	1,71	0,12	0,50	2,34	0,16	0,80	0,16	15	-	0,66

Tab. 3: Paraíba do Sul Plume

Station #	Depth (m)	NH4-N (µm)	NO2-N (µm)	NO3-N (µm)	NIT-N (µm)	PO4-P (µm)	POD (µm)	POP (µm)	N:P (µm)	SESTON (mg/dm3)	Chl.a (µg/dm3)
12. Dezember 1994											
#2	1	1,83	0,10	0,54	2,47	0,68	0,14	0,06	3,6	16,4	0,18
	10	1,51	0,10	0,36	1,97	-	-	0,04	5,9	1,3	0,00
#3	1	0,27	0,06	0,08	0,41	0,07	0,00	0,15	5,9	2,1	0,44
	7	1,45	0,04	0,51	2,00	-	-	0,10	15,6	1,7	0,17
#4	1	1,45	0,06	0,68	2,19	0,14	0,00	0,14	15,6	5,1	0,19
	7	1,51	0,15	-	0,00	-	-	0,12	-	3,9	0,30
#5	1	1,45	0,08	0,06	1,59	0,07	0,05	0,19	22,7	8,2	0,26
#6	2	1,39	0,08	0,45	1,92	0,09	0,07	0,10	21,3	36,6	0,47
#7	2	1,51	0,06	0,36	1,93	0,14	0,05	0,05	13,8	4,6	0,14
#8	2	1,51	0,08	0,61	2,20	0,09	0,09	0,09	24,4	4,8	0,05
13. Dezember 1994											
#9	2	1,51	0,08	3,15	4,74	-	-	-	-	9,6	0,68
#15	5	1,39	0,04	0,44	1,87	-	-	0,03	-	3,4	0,29
	20	1,39	0,06	0,31	1,76	-	-	0,06	-	3,6	0,16
#16	5	1,45	0,04	0,23	1,72	-	-	-	-	3,3	0,07
#16	15	1,76	0,04	0,44	2,27	-	-	0,08	-	3,7	0,09
14. Dezember 1994											
#18	1	1,89	0,13	0,26	2,19	-	-	0,14	-	6,7	0,39
	5	1,43	0,11	0,19	1,73	-	-	0,10	-	4,7	0,05
	10	1,76	0,10	0,21	20,70	-	-	0,09	-	5,3	0,42
#20	2	1,37	0,11	0,21	1,69	-	-	0,12	-	5,6	0,23
	7	1,50	0,11	0,17	1,78	-	-	0,11	-	5,7	0,27
#21	2	1,43	0,11	0,17	1,71	-	-	0,15	-	6,9	0,36
	7	1,37	0,13	0,22	1,72	-	-	0,17	-	8,1	0,80
#23	1	1,88	0,06	0,68	2,62	0,13	0,03	0,19	20,2	16,9	0,37
	3,5	1,59	0,06	0,34	1,99	0,14	0,03	-	14,2	13,3	1,05
	7	1,53	0,04	0,19	1,76	0,10	0,11	0,12	17,6	12,2	0,47
#26	1	1,53	0,04	0,25	1,82	0,08	0,18	0,02	22,8	10,9	0,73
	6	1,65	0,04	0,25	1,94	0,05	0,14	0,08	38,8	8,8	-
#27	1	1,53	0,04	0,25	1,82	0,12	0,08	0,08	15,2	4,0	0,14
	7	1,65	0,02	0,27	1,94	0,12	0,14	0,07	16,2	3,3	0,12

II. The isotopic composition of particular organic matter in the Rio Paraibo do Sul and Rio Doce estuaries

P. Kähler (IOW) & M. Voss (IOW)

Introduction

Stable isotope content of particular organic matter can be used to identify its sources (riverine or terrestrial POC carrying a signature different from marine), or processes which change its isotopic composition (e.g. nutrient uptake selective for lighter isotopes).

The $\delta^{15}N$ and $\delta^{13}C$ content of particular organic matter (POM) was used to study the fate of riverine (POM) in the estuaries of Rio Paraiba do Sul and Rio Doce. Samples were taken in the water column at stations off the coast in the respective rivers' plumes, down the course of the Paraibo do Sul, drifting sediment traps deployed off the mouths of both rivers, and in surface sediments within the ranges of both rivers' plumes.

So far, the water column samples and the trap samples have been analysed for their content of $\delta^{15}N$ and $\delta^{13}C$. In this preliminary report, data will be listed and the most obvious peculiarities of isotope distribution be discussed. A comprehensive explanation of all observations is not attempted at the present stage.

Results

In Tables 1 to 4 the values of particular organic carbon (POC) and Nitrogen (PON), and the $\delta^{13}C$ and $\delta^{15}N$ values are listed. For location of the respective stations and drift tracks of the sediment traps see Knoppers (leg 1, cruise report).

Suspended material

High salt contents show that in all samples collected in the two rivers' plumes the marine influence predominates. Mixing of freshwater and seawater obviously takes place closer to the shore where the ship's draft prevented sampling. In the case of the river Paraiba do Sul, where a small craft sampled the river, mixing took place in the surf zone where sampling was dangerous, so here only samples close to the end members of mixing were taken.

In the case of the Rio Doce plume, the characteristics of the POM shows that its composition is not a result of simply mixing river and sea water. At Stations 29 to 40, close to the river's mouth, markedly higher contents of ^{15}N were encountered than at stations 51 to 54, away from the river, although in both areas very similar (marine) salt concentrations were measured. A tentative explanation is that resuspended sedimentary material of riverine origin dominates the suspended POC at the time of sampling off the Rio Doce mouth. Its high $\delta^{15}N$ and low C/N-ratio are indicative of already degraded material. ^{15}N-enrichment in POM degradation residues is a common observation, but the reason for this ^{15}N enrichment is not clear. Another possibility is that estuarine nutrient dynamics has produced the signal in the offshore sediments: selective uptake of light nitrogen isotopes in the river with heavier ones remaining in the plume.

For the Rio Paraiba do Sul $\delta^{15}N$ varies between 6 and 11 both in the river and the plume, with no marked differences or recognizable regional trends (down the river or with distance from the river's mouth). Hence, the suspended PON cannot serve as a tracer for riverine/terrestrial POM at this place in our study.

^{13}C content varies only little in all areas, values of $\delta^{13}C$ around 22 are typical of marine material. Terrestrial material is generally lighter - as can be seen in the Rio Paraibo (riverine) samples. C4-plant residues, however, are isotopically heavy and probably influence the riverine signal to the opposite direction, at least in its sinkable fraction (see below). The material collected in the traps had a different isotope signature from the bulk suspended material.

Tab. 1: Contents of particulate carbon and nitrogen and their stable isotope composition in the RIO PARAIBA DO SUL PLUME

Station	Date 1994	Time	Depth [m]	Temp. [°C]	Sal. [o/oo]	POC [µmol/l]	PON [µmol/l]	δ 13C	δ 15N	Seston [mg/l]	Chl a [µg/L]	C/N ratio
2	12.12.	10:31	1	24,4	36,42	12,01	1,31	-24,17	6,44			9,17
	12.12.		10	24,3	36,49	6,41	0,81	-24,38	8,44			7,91
3	12.12.	14:00	1	25,2	34,5	18,27	2,28	-23,11	9,32	2,1	0,44	8,01
	12.12.		7	24,6	35,7	10,76	1,43	-22,77	9,72	1,7	0,17	7,52
4	12.12.	16:00	1	24,6	35,5	16,51	1,95	-21,84	10,38	5,1	0,19	8,47
	12.12.		7	24,6	35,75	10,99	1,49	-22,12	7,98	3,9	0,3	7,38
5	12.12.	17:00	1	25,2	35	17,24	2,24	-21,55	9,46	8,2	0,26	7,7
6	12.12.	19:00	2	24,7	36,1	17,98	2,39	-21,64	9,74	36,6	0,47	7,52
7	12.12.	20:00	2	24,5	36,35	11,39	0,93	-25,64	10,35	4,6	0,14	12,25
8	12.12.	21:00	2	24,9	35,9	8,37	1,05	-23,48	9,94	4,8	0,05	7,97
9	13.12.	9:50	2	24,8	33,7	18	2,29	-21,13	7,57	9,6	0,68	7,86
15	13.12.	18:00	5	22,2	36,77	9,28	1,05	-23,59	8,16	3,4	0,29	8,84
	13.12.		20	21,7	36,8	9,3	1,07	-24,6	7,52	3,6	0,16	8,69
16	13.12.	21:45	5	22,1	36,55	8,26	0,96	-24,52	7,98	3,3	0,07	8,6
	13.12.		15	22,1	36,55	7,98	0,84	-23,56	7,04	3,7	0,09	9,5
18	14.12.	11:05	1	25,6	35,77	14,27	1,78	-22,22	8,41	6,7	0,36	8,02
	14.12.		5	25,4	35,82	10,49	1,27	-22,89	8,23	4,7	0,05	8,26
	14.12.		10	23,5	36,48	10,97	1,14	-24,23	7,14	5,3	0,42	9,62
20	14.12.	18:00	2	24,6	36,35	12,24	1,24	-22,81	7,99	5,6	0,23	9,87
	14.12.		7	24,4	36,52	14,11	1,44	-24,47	7,76	5,7	0,26	9,8
21	14.12.	6:00	2	24,3	36,97	14,38	1,48	-22,86	7,44	6,9	0,36	9,72
	14.12.		7	24,2	36,1	15,46	1,62	-22,02	7,42	8,1	0,8	9,54
23	14.12.	11:30	1	25,7	35,9	31,01	3,84	-22,18	7,96	16,9	0,37	8,08
	14.12.		3,5	25,7	36,28	27,83	3	-21,82	7,63	13,3	1,05	9,28
	14.12.		7	24,7	36,36	22,89	2,42	-23	7,2	12,2	0,47	9,46
26	14.12.	19:15	1	26	34,6	14,89	1,47	-25,02	4,74	10,9	0,73	10,13
	14.12.		6	23,8	36,5	17,98	1,89	-23,74	9,43	8,8		9,51
27	14.12.	8:15	1	24	36,4	9,38	1,23	-23,62	8,19	4	0,14	7,63
	14.12.		7	23,4	36,55	8,62	1,2	-23,6	8,9	3,3	0,12	7,18

Tab. 2: Contents of particulate carbon and nitrogen and their stable isotope composition in the RIO PARAIBA DO SUL

Station	Date 1994	Depth [m]	Temp. [°C]	Sal. [o/oo]	POC [µmol/l]	PON [µmol/l]	δ 13C	δ 15N	Seston [mg/l]	Chl a [µg/L]	C/N ratio
A	15.12.	1	28,8	0	76,77	6,55			24,5	2,99	11,72
B	15.12.	1	28,6	0	94,07	9,8	-23,88	8,17	44,1	3,96	9,6
C	15.12.	1	28,4	0	95,54	9,98	-24,45	9,08	18,4	2,8	9,57
D	15.12.	1	28	0	89,24	8,06	-25,03	11,03	32	3,33	11,07
E	15.12.	1	27,8	0,5	67,28	7,55	-24,15	4,55	29,2	5,5	8,91
F	15.12.	1	28	0	118,97	10,41	-23,82	10,74	18,8	11,27	11,43
G	15.12.	1			75,44	8	-25,6	7,55	15,6	3,66	9,43
H	15.12.	1		32	24,5	2,81	-21	7,56	49	1,69	8,72
I	15.12.	1		31	18,58	1,53	-21,25	7,95	44,3	1,19	12,14
J	15.12.	1	26	34,2	15,97	1,62	-21,72	8,14	33,5	0,74	9,86
K	15.12.	1	25,7	35,9	21,14	2,14	-23,09	5,72		0,66	9,88

Tab. 3: Contents of particulate carbon and nitrogen and their stable isotope composition in the RIO PARAIBA DO SUL PLUME

Station	Date 1994	Time	Depth [m]	Temp. [°C]	Sal. [o/oo]	POC [µmol/l]	PON [µmol/l]	δ 13C	δ 15N	Seston [mg/l]	Chl a [µg/L]	C/N
29	17.12.	0:50	10	26	36,95	7,16	0,92	-21,75	12,84	23,1	0,09	7,78
32	17.12.	11:00	2	23	36,41	62,96	16,76	-23,22	24,86	20,5	2,07	3,76
	17.12.		7	21,1	36,55	31,69	5,36	-23,88	22,75	11	0,98	5,91
34	17.12.	18:20	2	22,3		32,53	6,48	-24,2	19,34	12,2	0,84	5,02
	17.12.		7	21,5	36,65	31,1	5,2	-23,68	19,48	10,2	0,83	5,98
38	18.12.	12:00	1	23,4	36,15	48,4	7,02	-22,83	11,86	17,9	2,85	6,89
	18.12.		7	21,6	36,75	61,7	9,3	-23,88	11,25	18,5	1,27	6,63
40	18.12.	18:10	2	22,5	36,1	21,1	2,26	-22,1	9,41	12,4	0,66	9,34
	18.12.		15	19,8	36,63	25,83	3,64	-24,26	10,02	24,3	0,59	7,1
41	19.12.	8:10	2	22,6	35,3	13,91	1,71	-24,05	10,1	9,5	0,43	8,13
	19.12.		7	22,2	36,01	13,68	1,75	-23,38	6,27	12,8	0,57	7,82
51	19.12.	14:55	2	22	36,6	14,81	2,16	-23,42	9,25	4,6	0,95	6,86
	19.12.		7	21,4	36,55	16,02	2,03	-22,92	8,62	5,2	0,69	7,89
	19.12.		15	19,2	36,55	15,38	1,85	-24,27	7,55	6	0,5	8,31
52	20.12.	10:05	2	22,4	36,15	13,19	1,79	-23,21	7,59	4,8	0,47	7,37
	20.12.		7	21,5	36,55	15,98	2,51	-22,41	7,16	4,9	1,25	6,37
	20.12.		12	20,1	36,42	11,75	1,91	-23,69	7	15		6,15
53	20.12.	13:20	2	22,7	36,24	13,74	2,05	-22,98	7,05	4,4	0,61	6,7
	20.12.		7	20,7	36,66	12,98	1,82	-23,09	7,66	4,6	0,61	7,13
54	20.12.	9:10	2	24,7	36,55	10,62	1,49	-24,62	8,23	8,4	0,26	7,13
	20.12.		7	24,5	36,53	10,25	1,46	-24,48	6,38	0,3	0,33	7,02
	20.12.		13	20,4	36,7	18,18	2,55	-24,39	6,45	3,9	0,23	7,13

Trap material

For the Rio Paraiba do Sul (cups 1 to 3), it is evident that the traps collected material which is totally different from the bulk POC both in the river and the estuary. Its C/N-ratio is extremely high, and also high $\delta^{15}N$-values characterize this material. Its high $\delta^{13}C$ is characteristic of C4 plants, pointing to its most probable origin: a sugarcane processing plant on the river. Although it dominates the sinkable POC - the nearer to the river's mouth, the more the traps collected, and the more is the collected material dominated by the sugarcane residues - the bulk material in the river and coastal waters has a different composition.

Also in the waters off the Rio Doce mouth, sinkable POC differs from bulk DOC, but in a different way. The sinkable fraction is lower in $\delta^{15}N$ than the suspended material; it is also lower than the sinkable material in the Rio Doce plume. The $\delta^{13}C$ do not differ from that of the suspended material. The ^{15}N signature may reflect the selective uptake of isotopically light nitrogen (ammonia?) and indicate that the sinkable material is dominated by freshly formed phytoplankton, which can be checked for by microscopic inspection of the samples.

Tab. 4: Contents of particulate carbon and nitrogen and their stable isotope composition in the material collected by sediment traps in the Rio Paraíbo do Sul and Rio Doce plumes. Values are not corrected for split ratio, collecting interval, and sampling area of traps.

Split factors: 1=150; 2=300; 3=150; 4=300; 5=300; 6=150; 7=25; 8=25

area	cup no. x	µmol N (per split & collecting interv.)	µmol C (per split & collecting interv.)	δ15N	$\delta^{13}C$	MW δ15N	MW δ 13C	C/N ratio
Plume	1b	3,49	107,88	4,52	-7,86			30,91
Rio Paraibo	1c	9,64	332,48	7,98		7,98	-7,86	34,49
	1d	4,16	148,75					35,76
	2a	3,87	91,14	7,74	-10,27			23,55
	2b	4	81,7	7,8	-10,61			20,43
	2c	4,26	122,83	7,37		7,03	-10,44	28,83
	2d	3,76	99,34	6,68				26,42
	3a	2,03	27,65	6,98	-17,84			13,62
	3b	1,96	27,41	7,29	-15,97			13,98
	3c	1,55	38,09	6,17		6,18	-16,91	24,57
	3d	1,7	36,85	6,18				21,68
Plume	4a	3,47	35,94	6,52	-19,78			10,36
Rio Doce	4b	3,25	34,75	5,98	-19,72			10,69
	4c	3,34	14,43	5,77		5,86	-19,75	4,32
	4d	3,38	14,07	5,95				4,16
	5a	2,56	27,62	5,04	-22,91			10,79
	5b	2,69	26,12	5,82	-22,35			9,71
	5c	1,59	36,1	5,49		5,76	-22,63	22,7
	5d	2,66	36,67	6,02				13,79
	6a	1,54	15,99	6,42	-22,81			10,38
	6b	1,75	16,22	6,5	-22,57			9,27
	6c	2,59	24,09	5,07		5,31	-22,69	9,3
	6d	1,42	21,62	5,55				15,23
	7a	2,06	16,02	6,73	-23,14			7,78
	7b	2,23	16,54	6,62	-22,51			7,42
	7c	1,83	19,44	5,62		5,52	-22,83	10,62
	7d	1,65	19,03	5,42				11,53
	8a	3,71	21,49	6,38	-22,08			5,79
	8b	4,48	29,58	6,13	-21,45			6,6
	8c	4,13	35,42			4,96	-21,77	8,58
	8d	3,79	31,4	4,96				8,28

III. Distribution of polycyclic aromatic hydrocarbons in sinking particles and surface sediments from coastal environment of eastern Brazil

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In addition to the elucidation of transport pathways, origin and dynamics of biogenic matter (see report of B. Knoppers and report of P. Kaehler) the aim of leg 1 was to investigate the distribution and fate a) of pollutant metals and b) of polycyclic aromatic hydrocarbons (PAH's) as typical organic micropollutants in coastal waters of eastern Brazil. The present report focusses on the distribution of the PAH's in the three regions under investigation while analyses of trace metals in the various matrices are still in the state of processing.

Abstract

Six samples of surface sediments were collected along the eastern Brazilian coast in three regions. Two regions were close to the mouths of the river Rio Paraiba do Sul and the river Rio Doce. Both rivers which are known to suffer from anthropogenic impact carry large amount of biogenic materials partly derived from sugar cane processing to the coastal zone. The third coastal region receives no direct input from rivers and may be considered relatively unpolluted. From shallow water depths of these three regions also eight samples of sinking particles were collected by using sediment traps. The polycyclic aromatic hydrocarbons (PAHs) in the samples were isolated by solvent extraction and column chromatography and then identified by HPLC (additional confirmation by GC and GC/MS is not finished). Quantification was by HPLC employing fluorescence and UV detection. The general pattern of environmental contamination with PAHs changes regionally in a similar way for both trapped particles and for the underlying sediments: there is a trend for higher concentrations toward the north. Unexpected results were the low contamination levels in the Rio Paraiba do Sul region and comparably high concentrations in the third region. High concentrations, however, in trapped particles of the third region do not imply high contaminant fluxes to the sea floor because the total particulate flux was much smaller than the fluxes observed in the two river plumes. High concentrations of phenanthrene in the third region together with higher PAH concentrations in the trapped particles as compared to sediments point to a temporally enhanced contamination of the water column which might originate from petroleum discharge.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are known to occur widely in sedimentary environments. Some PAHs have been shown to be mutagens and carcinogens in various laboratory experiments. Thus, knowledge of the sources and global distribution of PAHs in sedimentary environments is important because of the effects these compounds can have on biological systems. The major source of this contamination is assumed to be anthropogenic, resulting from the incomplete combustion of fossil fuels. Of minor significance in most coastal environments is the natural burning of wood. Air- and waterborne transport of particulates has been suggested as a mechanism for the broad dissemination of PAHs from these sources. Prominent point sources are petroleum and coal terminals, petroleum refineries, major sewage treatment plants and other industries. After entering hydrologic systems most PAHs are associated with particulate matter due to the low water solubility of these compounds. PAHs finally accumulate in bottom sediments which can then act as a long term reservoir maintaining concentrations in the overlying water column and its organism assemblage.

The present study was undertaken in order to assess the occurrence and distribution of PAHs in sediments and particles from the water column of three Brazilian coastal regions characterized by different anthropogenic impact. In addition, possible relationships among the different PAHs would be evaluated to identify potential origins.

Materials and Methods

Study area

The area along the Brazilian coast investigated extends from the Rio Paraiba do Sul (21°37 S, 39°41 W) to the river Rio Doce (19°39 N, 39°48 W) and was divided into three regions which are depicted in Fig.1. The regions I and II are close to the mouths of the Rio Paraiba do Sul and Rio Doce , respectively. The Rio Paraiba do Sul carries materials from urban activity and is known for its large discharge of biogenic matter arising from sugar cane processing. Present knowledge suggest that the Rio Doce (region II) suffers much less anthropogenic impact, but still discharges great amounts of terrigenic particles to the coastal environment. The third region to the south of the Rio Doce was selected as a reference area that does not receive direct input of riverine terrestrial materials and is relatively remote from urban discharges. Thus, particle dynamics of region III should have the strongest contribution from marine particle production as compared to the other two regions.

Sample collection

All sample collections were carried out during December 1994 (southern early summer) by using the facilities of RV Victor Hensen. Sediments from water depths of 10-17 m (see report B. Knoppers) were collected with a grab sampler from which the top 2 cm of the apparently undisturbed surface sediments were taken with a metal spoon. Because these shallow water sediments contained different amounts of coral rubble and other coarse materials, comparison between different locations is only possible when reference is made to the fine fraction which normally is assumed to contain most of the micropollutants. Therefore, the frozen sediment samples were thawed and wet sieved to isolate the fraction <63 µm for subsequent extraction. Sinking particles were sampled by using a drifting sediment trap with two funnels with an opening of 1.06 m^2 and a collecting glass jar. These traps being deployed at water depths between 6 m and 9 m (i.e. below the halocline) were run for periods of 0.3-1.0 days. Particles collected with these sediment traps are a mixture of particles sinking out of the water column and of particles resuspended from surface sediments. In the regions I and II the drifting sediment traps were placed in the river plumes which were clearly discernible by their colour gradients. Particles trapped in large amounts in these two regions all contain primarily the terrestric signature. Drift tracks for the different deployments are shown in the report of B. Knoppers. Since the sampling devices had to serve different purposes, contact of the samples with different polymeric materials could not be excluded. The occurence of unusual peaks (e.g. phthalic esters) in the chromatograms was noted and taken into consideration.

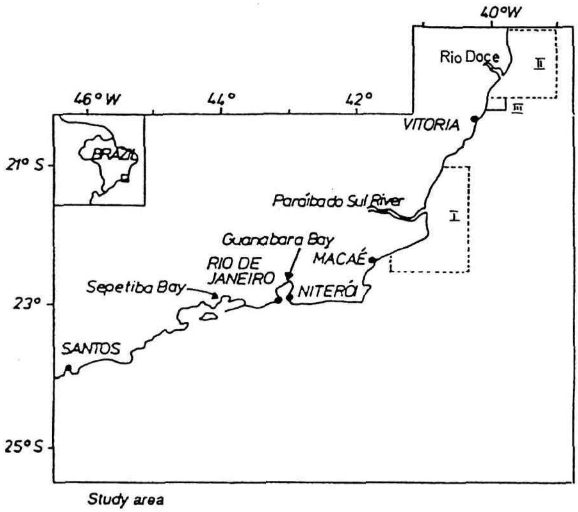

Fig. 1: Area under investigation in Brazilian waters showing the three regions that were sampled in detail: region I close to the mouth of Rio Paraíba do Sul, region II close to the mouth of the Rio Doce, and region III relatively remote from the input by the rivers of urban activity

Analysis

The extremely small amounts of particulates of the samples from the sediment traps (ranging from 23 mg to 1092 mg) frozen together with the overlying water were thawed and centrifuged. The wet residue was extracted three times with 3 ml portions of methanol followed by three extraction steps using 3 mL portions of dichloromethane in an ultrasonic bath. Afterwards the extracted material was dried at 50∞C and weighed. The extracts were combined, evaporated down to 1-2 ml (water) and mixed with the same volume of preextracted (CH_2Cl_2) 10% sodium chloride solution. This mixture was then extracted three times with (CH_2Cl_2) and the organic layer dried with anhydrous sodium sulphate. Because of the low PAH content of the original samples the organic extracts were separated into aliphatic and aromatic hydrocarbon fractions in only one chromatographic step using alumina (6 g, 4.5% water). Three fractions of increasing polarity were obtained by eluting first with 18 mL hexane (aliphatic hydrocarbons) followed by 20 mL hexane/dichloromethane (3:1; fraction containing the PAHs), and finally by 20 mL hexane/dichlormethane (1:1; fraction that may contain higher PAHs such as coronene as well as PAH oxidation products, e.g. ketones; also analysed to check for the efficiency of the previous separation).

The fractions of fine sediment were freeze dried and Soxhlet-extracted with the acetone/hexane azeotrope. This raw extract was first percolated through activated copper to remove sulfur. The subsequent separation into different fractions was performed in two steps: (1) Sephadex LH-20 which mainly served to remove an early pigment fraction and (2) alumina to separate three hydrocarbon fractions as described above. Recovery estimates for the PAHs were found acceptable after subjecting reference materials to the same procedure.

The purified PAH-fraction was concentrated and the eluant was displaced with acetonitrile for HPLC gradient analysis which was performed using a low pressure gradient mixing pump combined with a fluorescence and an UV detector in series. The column was a 250 mm x 4.6 mm inside diameter RP-18 column (BakerBond) with a particle size of 5 μm. The programmable pump ran a system of acetonitrile and water with a gradient from 55% to 100% acetonitrile. During the run the fluorescence detector wavelengths were switched several times to achieve optimal conditions for excitation and emission. In general, PAHs were identified on the basis of their retention time and quantified by comparison with the fluorescence response of the appropriate standard.

To confirm the identity of the different peaks and to obtain information about compounds not contained in the standard EPA mixture of 16 PAHs, several samples were subjected to an additional GC and GC-MS analysis that up to now has not been finished. *For GC analysis the PAH extracts in acetonitrile were displaced into hexane. Preliminary identification of PAHs was made using a Siemens (model Sicromat 2) gas chromatograph equipped with a fused silica capillary column (0.32 mm i.d. x 25 m, BPX5, 0.25 μm film thickness) and a flame ionization detector.* The PAH fraction was chromatographed using splitless injection and employing temperature programming (2 min hold at 50°C, from 50°C to 120°C at 20°C/min, from 120°C to 300°C at 3.5°C/min). Confirmation of the GC identifications by retention times will be accomplished by GC-MS by using a Varian gas chromatograph (Mod.3400) equipped with a fused silica capillary column (0.32 mm i.d. x 30 m, DB5) and coupled to a Finnigan mass-spectrometer (MAT8200).

Results

Due to the low absolute amounts of PAHs in the samples only the following 12 compounds of the standard EPA mixture of 16 priority pollutant PAHs were considered (naphthalene, acenaphylene and acenaphthene were below the detection limit or not present): phenanthrene (PHEN), anthracene (ANTH), fluoranthene (FLA), pyrene (PYR), benzo[a]anthracene (BAA), chrysene (CHRY), benzo[b]fluoranthene (BBFLA), benzo[k]fluoranthene (BKFLA), benzo[a]pyrene (BAPYR), dibenzo[a,h] anthracene (DBANT), benzo[ghi]perylene (BPERY), and indeno[1,2,3-cd]pyrene

*Tab. 1: Split weight, duration, extrapolated total mass and total mass flux of particles as obtained during the eight drifting sediment trap experiments (ST1-ST8) in the three regions investigated in Brazilian coastal waters (**I**: Rio Paraíba do Sul plume; **II**: Rio Doce plume; **III**: region devoid of major river input). For the drift tracks of the sediment traps, see: report B. Knoppers.*

Region	Trap No.	Split-dw [mg]	Duration [days]	Total-dw [g]	Flux [g*m-2*d-1]
I	ST1	785	0,815	11,78	13,63
	ST2	1092	0,358	16,38	43,16
	ST3	143	0,567	2,15	3,57
II	ST4	619	0,372	9,29	23,55
	ST5	490	0,249	7,35	27,85
	ST6	99	0,612	1,49	2,29
III	ST7	32	0,858	0,16	0,18
	ST8	23	1	0,12	0,11

(IPYR). In addition, perylene concentration was estimated from the gas chromatogramms by using a GC-response-relative retention time regression expression obtained experimentally.

The principal source of PAHs is the incomplete combustion of organic material, with the composition of the PAH assemblage being determined partly by its temperature of formation. Higher temperatures and more complete combustion produce higher proportions of parent aromatics with fewer substituted carbon side chains. PAHs from oils and coals (produced from organic matter over millions of years at relatively low temperature) are highly substituted whereas those from fires have fewer carbon side chains and those from high-temperature industrial processes are almost entirely parent compounds.

In addition to wood burning and bush fires local sources in the study area could comprise: atmospheric transport from cities of the wider surrounding region, input of contaminated particles

Tab.2: Position of the sediment samples (S1-S6) collected in the three regions I-III and the station number used on board. Since only minor amounts of fine material could be sieved from the sediments at the stations of region III, the fractions of fine sediment from stations #56 and #57 were combined to form S6.

Region	Sediment No.	Station No.	Depth [m]	Latitude	Longitude
I	S1	9	11	21°48.4´S	40°58.9´W
	S2	23	11	21°36.7´S	40°59.0´W
	S3	13	10	21°33.6´S	41°00.4´W
II	S4	49	16,5	19°44.5´S	39°56.8´W
	S5	46	14	19°41.7´S	39°51.5´W
III	S6	56	16	19°51.0´S	40°02.2´W
		57	13	19°56.6´S	40°09.3´W

with the rivers, discharge from terminals and sewage plants of the city of Vitoria, petroleum losses from shipping terminals along the coast for unloading and loading of fossil fuels and ores, respectively. Closer examination in the next future of compounds not enclosed in the EPA list (e.g. alkylated phenathrenes etc.) might give clues to the relative proportions of petroleum derived PAHs and those originating from combustion processes.

A convenient way of comparing concentrations of PAHs derived from combustion is by using the sum of several parent compounds under the term combustion products (SCOMB). The exact compounds used for this calculation vary from study to study, but mostly include 9-12 unsubstituted hydrocarbons. Under the term SCOMB we have summed here 9 compounds: fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[g,h,i]perylene and indeno[1,2,3-cd]pyrene.

Trapped particles

The concentrations of the selected individual PAHs (in: ng/g) in the particles obtained from drifting sediment traps (ST1-ST8) are shown in Tab.3 (the concentrations listed are preliminary because complete confirmation by GC and/or GC-MS is still in progress). In region I and II from where always more than 99 mg per sample had been extracted, all 12 PAHs were detected in at least one sample, but most PAHs occurred in all these particulate samples although some of the individual compounds were close to the detection limit. Generally the particles from region I (Rio Paraiba do Sul) which was assumed to show the strongest anthropogenic signal are much less contaminated with PAHs than those from the region close to the mouth of the Rio Doce. This holds for the sum of all PAHs determined (TPAH) as well as for all individual com-pounds except for PHEN. Particles trapped in region III had surprisingly high PAH concentrations which, however, require further corroboration because the signals were low for most individual compounds due to the low amount of material available for

Tab. 3: Concentrations of selected individual PAHs (in: ng/g; for abbreviations: see text) in the particles obtained from drifting sediment traps (ST1-ST8). The concentrations listed are preliminary because confirmation by GC and GC/MS is still in progress

Region Trap No.	ST1	ST3	ST2	ST7	ST8	ST6	ST4	ST5
PHEN	5,5	12,7	23,7	112,4	N.D.	15,2	12,4	28,5
ANTH	0,5	6,6	N.D.	16,5	N.D.	2	2,8	5,8
FLA	18	N.D.	10,9	127,6	178	93,2	208,2	266,7
PYR	22	20,8	N.D.	186,1	151	153,2	184,4	2235,7
BAA	10,5	10,2	66,7	110,3	120,9	78,3	118,8	156
CHRY	13,3	8,9	59,9	88,2	172,6	89,1	116,8	153
BBFLA	25,5	37,8	79,5	203,3	293,1	147	179,4	233,2
BKFLA	13,1	17,7	38,7	69,2	87	56,8	83,1	96
BAPYR	26,6	29,5	84,1	134,7	169-5	124,8	179,3	226,3
DBANT	4,5	12	9,2	N.D.	N.D.	N.D.	17,3	27,3
BPERY	27,7	33	57,1	86,8	165,9	107,4	140,7	180,1
IPYR	24,4	56	83,3	140	243	245,4	82,3	130,2
TPAH (ng/g)	191,6	245,2	513,1	1275,1	1581,9	1112,4	1325,5	1738,8
SCOMB (ng/g)	81,1	213,9	480,2	1146,2	1581,9	1095,2	1293	1677,2

extraction. The relative abundance of the individual compounds within the group of pyrolytic PAHs (SCOMB, see above) showed no significant differences between the regions thus suggesting a common source. The distribution of TPAHs and SCOMB as defined above in the different regions is shown in Fig.2. The unexpectedly high levels for ST7 and ST8, however, do not necessarily imply a regional focus of contamination because the amount of particles trapped in this region III was extremely low. When assuming that the trapped particles represent the true flux of particles settling to the sea floor, the corresponding PAH fluxes can be calculated from the concentrations and the total mass flux (Tab.1). The respective fluxes of total PAHs together with the flux of SCOMB are depicted in Fig.3 which clearly shows that the contaminant flux per unit area and time in re-

Fig.2: Distribution of total PAHs (TPAH, sum of concentrations of 12 compounds, in: ng/g) and of "combustion PAHs" (SCOMB, sum of concentrations of 9 selected compounds, in: (ng/g) in particles trapped from the water column (ST1-ST8) of Brazilian coastal environments

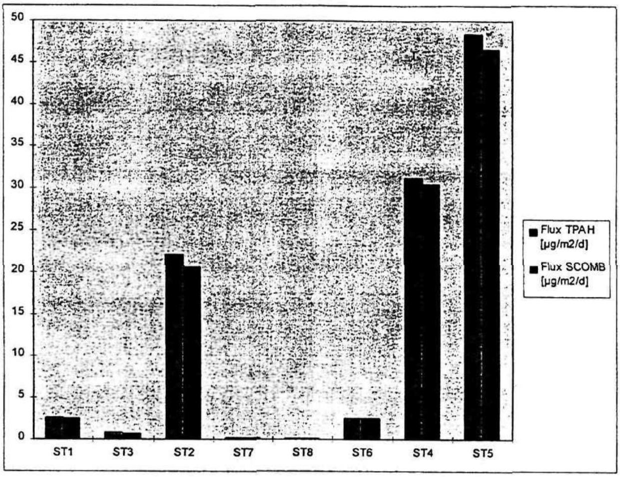

Fig. 3: Distribution of flux of total PAHs (TPAHs, sum of 12 ccompounds, in: $\mu g \cdot m^{-2} \cdot d^{-1}$) and combustion related PAHs (SCOMB, sum of 9 compounds, in: $\mu g \cdot m^{-2} \cdot d^{-1}$) calculated from the concentration of PAHs in the trapped material and the total mass flux. Note that region III has a much lower flux of PAHs as compared to the other regions.

gion III is much smaller than in the regions with large riverine input. The relationship between PAH concentration and PAH flux depends not only on the source strengths but also on the relative significance of different transport pathways (via the atmosphere vs via river particulate matter). Therefore, the observed higher concentrations in region III could also result from a dilution of atmospherically derived PAH-containing particles by the high riverine input to region I and II of relatively uncontaminated inorganic and organic particles.

Sediments

The concentrations of the selected individual PAHs (in: ng/g) in the sediments (S1-S6) are shown in Tab.4. In all sediments of the three regions the whole suite of the selected PAHs was detected although some of the individual compounds were close to the detection limit. Between the different regions a similar trend was found as decribed above for the trapped particles: two of the three sediments analysed from region I (Rio Paraiba do Sul) showed much less contamination with PAHs than those from the regions II and III further north. Again this holds both for the sum of all PAHs determined (TPAH) and for all individual compounds except for PHEN. All sediments taken close to the Rio Doce had very high levels in all pyrolytic PAHs. This group of compounds showed a continuous decline toward the south. A major difference between the two regions (I and II), that were dominated by riverine input of terrestric particles, was the occurrence of perylene at higher concentrations in the Rio Paraiba do Sul region. This was detectable both directly from the GC peaks and indirectly from the ratio of the detector responses for fluorescence and UV of BBFLA which coelutes with perylene in the HPLC.

Comparison of trapped particles and sediments

The concentrations of PHEN are generally higher in the sediments than in the particles caught from the water column. Although less pronounced the same holds for fluoranthene (FLA). The pyrolytic PAHs show a different pattern: in region I and II with high riverine input the concentrations of pyrolytic PAHs are similar in both trapped particles and in the sediments; in region III, however, trapped particles exhibit higher concentrations than the sediments that might be explained by a temporally increased contamination of the water column.

Comparison of the three regions

Both in trapped particles and in the sediments the sum of all PAHs determined generally increased from south to north with partly elevated values in region III which is situated between the two river plume dominated regions. Therefore, the expected higher contamination of region I in the plume of

Tab.4: Concentrations of selected individual PAHs (in: ng/g; for abbreviations: see text) in the fine fraction of sediment (S1-S6). The concentrations listed are preliminary because confirmation by GC and GC/MS is still in progress.

Region		I		III	II	
Station No.	9	23	13	56/57	49	46
Sediment No.	S1	S2	S3	S6	S4	S5
PHEN	55	32,3	68,4	188,9	38,9	118,9
ANTH	1,3	1,8	7,7	5,9	9,2	34,1
FLA	24,2	24,2	142,5	143,3	237,2	375,2
PYR	23,2	21,9	130,3	131,4	223,6	349
BAA	11,3	11,6	56,8	65,8	122,3	181,5
CHRY	13,2	11,1	60,2	79,9	119,4	164,6
BBFLA	13,2	69,9	100,6	69,2	167,3	239,4
BKFLA	4,8	7,1	35,6	33,2	79,3	111,4
BAPYR	9,3	15,7	81,5	70,4	172,1	244
DBANT	2,4	2,9	16,8	9,4	32,7	44,1
BPERY	8,4	14,1	75,4	56,5	135	171,9
IPYR	8,6	15,9	123,4	67,7	177,3	209,1
TPAH [ng/g]	175	229	899	922	1514	2243
SCOMB [ng/g]	116	192	806	717	1434	2046

the Rio Paraiba do Sul cannot be confirmed, while PAH levels in the Rio Doce plume, on the other hand, are even comparable to levels found in coastal environments of industrialized regions of the world. The pattern of increasing concentrations toward the north was most pronounced for selected PAHs which are typical for combustion processes. It is much more difficult to detect the contamination by unburned fossil fuels (petroleum) as the second main source of PAHs. Because unburned fuels contain relatively high amounts of low molecular weight hydrocarbons with one-, two- and three-ring aromatics the dominant occurrence of phenanthrene or ratios of other PAHs with respect to phenanthrene were often suggested for the identification of a strong contribution of unburned fossil fuels. Ratios between pyrolytic PAHs and PHEN in our samples suggest a relatively high contribution of petroleum to the water column of region III. Perylene which is thought to be derived from natural terrestrial sources shows higher concentrations in all sediments and particles of the Rio Paraiba do Sul region and much lower levels in sediments and trapped particles of the regions to the north.

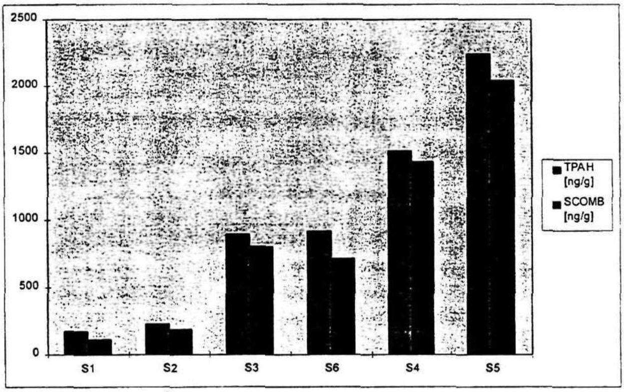

Fig.4: Distribution of total PAHs (TPAHs, sum of concentrations of 12 compounds, in: ng/g) and selected combustion related PAH (SCOMB, sum of concentrations of 9 compounds, in: ng/g) in the fine fraction of sediment (S1-S6) of Brazilian coastal environments

Leg 2: Biogeochemical cycling of carbon, metals and phosphorus at the land-sea interface: role of mangroves and small rivers

Chief Scientists: Dr. T. Jennerjahn (IBMC), Prof. Dr. R. Ovalle (UENF) (Leg 2a) and Prof. Dr. V. Ittekkot (IBMC) (Leg 2b)

Cruise report and first results

Introduction and objectives

The project was designed to assess the role of mangroves and small rivers for the cycling and deposition of carbon, phosphorus and metals on the brazilian continental margin. Continental margins play an important role in the biogeochemical cycling of elements. Particularly in tropical and subtropical areas mangroves might be of great importance for carbon exchange with the continental margin, because of their high biological productivity and high carbon and nutrient stocks. From the limited data sets existing to date it is estimated that around 5 - 10 % of the $0.75 * 10^9$ t C annually buried in continental margin sediments may be of mangrove origin (Lacerda, 1992; Walsh, 1988).

Regional differences in hydrography, morphology and freshwater input, however, make it difficult to assess the role of mangroves for the carbon cycle on a global scale. Mangroves can act as carbon sinks or sources, export can occur in particulate (e.g. SE-Asia; Wattayakorn et al., 1990) or in dissolved form (e.g. Florida; Twilley, 1985) or as a mixture of both. Input of mangrove- and river-derived material might enhance the formation of large, fast sinking aggregates and thus the flux of land-derived carbon to the seafloor. Those aggregates built by the interaction of biologically produced material and lithogenics provide means for a rapid transfer of particulate matter from surface waters to the deep sea. Particularly near continental margins this depositional mechanism is capable of integrating and transferring land-derived particulate matter to the seafloor.

Former joint projects of the Institute of Biogeochemistry and Marine Chemistry (IBMC) and the Universidade Federal Fluminense (UFF) MAR12 and MAR13 were focused on the transformation of land-derived material in mangroves (Lacerda et al., 1995) before its transfer to the sea and the sediment dispersal and deposition on the Brazilian continental margin. Results show that mangroves partially can act as carbon sources. On the one hand deposition of fine-grained sediments with high contents of organic carbon on the shelf is confined to river mouths suggesting that the combined particulate matter input of mangroves and rivers may be of minor relevance for the carbon burial in Brazilian continental margin sediments (Jennerjahn, 1994; Jennerjahn & Ittekot, subm.). On the other hand fine-grained sediments with organic carbon contents > 1 % accumulate in morphological traps on the upper slope (ca. 1 000 m water depth; Jennerjahn, 1994). Possible sources are (i) mangroves, (ii) rivers and (iii) marine production.

During JOPS-II detailed studies of water, particulate matter and sediments from mangroves, rivers and the continental margin should give clues on material sources, modes of transformation and transportation and the final area of deposition. Studies of sediment cores should provide similar information for the late Pleistocene. Furthermore a sediment trap system was deployed on the brazilian continental margin approximately 50 km off the São Francisco mouth in order to obtain information on quality and quantity of marine production, its possible seasonal variation and the possible contribution of land-derived material from mangroves and rivers.

Cruise objectives of JOPS-II legs 2a and 2b were:

- to deploy and recover a sediment trap system equipped with current meters near the São Francisco mouth area in 2 100 m water depth;

- to sample water, suspended matter and sediments from shallow shelf stations (10 m water depth) near mangrove areas and small rivers between 11° and 20°S;

- to retrieve cores (2 - 3 m long) from the upper slope (ca. 1 000 m water depth).

Investigated area

The investigated area between 11° and 20°S (Fig. 1) *is characterized by a narrow and shallow shelf* (10 - 30 km in width) and a steep and narrow upper slope (Emery & Uchupi, 1984). Between 16° and 19°30'S the shelf reaches a maximum width of up to 250 km on a broad carbonate platform, the Abrolhos archipelago. Continental slope morphology is determined by faults which mostly parallel the coast and hence the Precambrian basement. The coastal area is covered by dense mangrove vegetation mostly located in sheltered areas behind sand bars of early Holocene origin and mouths of several small rivers discharging into the Atlantic Ocean (e.g. Mabesoone & Coutinho, 1970). Discharge of the small rivers summed up is approximately on the *same amount*
as that of the Doce (20 $km^3\ yr^{-1}$), the largest river of the area. The hydrographic regime is governed by the southward directed Brazil Current, which separates in two branches at the Abrolhos archipelago. A larger part takes a shallow landward passage through the archipelago with maximum velocities around 0.70 $m\ s^{-1}$, while the seaward branch east of the Abrolhos archipelago reaches maximum velocities of 0.13 $m\ s^{-1}$ (Stramma et al., 1990). Nearshore surface currents are responsible for alongshore transport in northern as well as in southern direction depending on the seasonally varying wind direction and speed and river discharge.

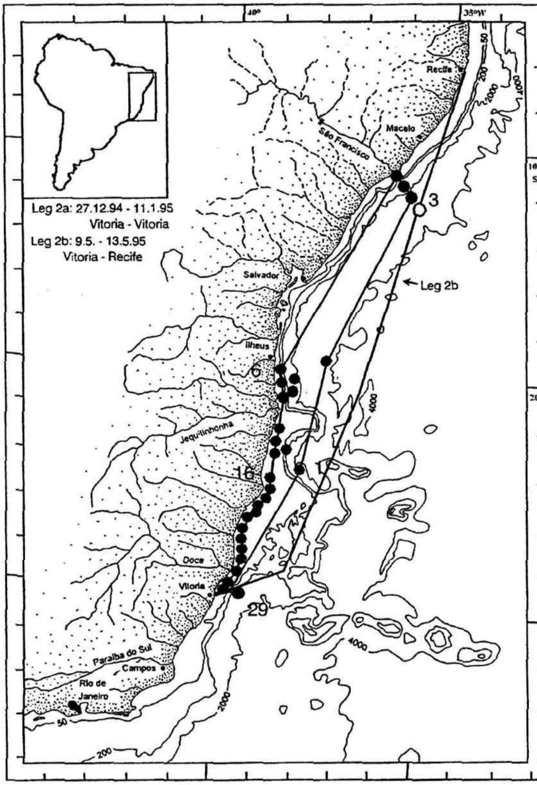

Fig. 1: Map of the investigated area with stations sampled during leg 2a and 2b

Operated gears and sampling

A ME Meerestechnik CTD-probe was used to record water column properties. Water samples from three depths were taken with 10 l Niskin bottles for analyses of dissolved organic carbon, dissolved oxygen, total alkalinity, pigments and nutrients. Furthermore surface water samples were taken for analyses of dissolved amino acids, amino sugars and carbohydrates.

Suspended matter from 2 m water depth was collected with a CEPA continuous flow lcentrifuge at a flow rate of 10 l water min^{-1}. Samples were dried at 40°C.

A Reineck box grab with a cross-section of 50 x 50 cm retrieved undisturbed sediment cores of up to 60 cm. Longer cores (up to 2.5 m) from the shelf and slope (up to 1 200 m water depth) were retrieved with a piston corer. The cores were photographed and described immediately after retrieval and then sampled for biological, geochemical, sedimentological and mineralogical analyses. Subsamples were taken for analyses of organic and inorganic carbon, nitrogen, biogenic opal, amino acids, amino sugars, carbohydrates, pyrolysis, ^{15}N, ^{13}C, phosphorus, metals, pigments, grain size distribution, clay mineralogy and separation of foraminifera shells for oxygen isotope analysis.

The sediment trap system (Fig. 2) consisting of two PARFLUX MARK 7G-21 sediment traps (21 cups each) each equipped with an AANDERAA RCM4 current meter was deployed in 2 100 m water depth at 10°56.4'S, 36°13.4'W and sampled particle flux in two water depths (500 m and 1 550 m). The traps were programmed to sample particle flux from January 4 to May 10, 1995 in 6-day intervals (Tab. 1). The AANDERAA RCM4 meters were programmed to monitor current speed and velocity throughout the whole sampling period at a resolution of two hours.

Total carbon and nitrogen were analyzed by high temperature combustion with a Carlo Erba (Milan, Italy) Elemental Analyzer NA-1500. Inorganic carbon was measured conductometrically with a Wösthoff (Bochum, Germany) Carmhograph 6. Biogenic opal was determined photometrically as silicomolybdate complex using a modification of Mortlock and Froelich's (1989) method. Organic carbon (C_{org}) was calculated as the difference between total carbon and carbonate carbon (C_{carb}). During the two cruise legs a total of 30 stations was occupied (Tab. 2).

Preliminary results

On May 12, 1995 the sediment trap system has been recovered successfully at 10°56.4'S, 36°13.4'W. The traps rotated correctly and the cups were in proper position. Visual inspection of the samples showed extremely small amounts of material in the upper trap while in all cups in the deeper trap roundabout 10 % of the cup volume (total volume 250 ml each) consisted of particulate matter. This pattern of particle deposition might be influenced by terrigenous matter introduced by the São Francisco as the sediment trap system was sampling particle flux during the high discharge period of the river (JENNERJAHN et al., in press).

Tab. 1. Rotation schedule of sediment traps. Date and time is UTC. Intervals started and ended at 0:01h UTC

Cup No.	Start	End
1	4.1.1995	10.1.1995
2	10.1.1995	16.1.1995
3	16.1.1995	22.1.1995
4	22.1.1995	28.1.1995
5	28.1.1995	3.2.1995
6	3.2.1995	9.2.1995
7	9.2.1995	15.2.1995
8	15.2.1995	21.2.1995
9	21.2.1995	27.2.1995
10	27.2.1995	5.3.1995
11	5.3.1995	11.3.1995
12	11.3.1995	17.3.1995
13	17.3.1995	23.3.1995
14	23.3.1995	29.3.1995
15	29.3.1995	4.4.1995
16	4.4.1995	10.4.1995
17	10.4.1995	16.4.1995
18	16.4.1995	22.4.1995
19	22.4.1995	28.4.1995
20	28.4.1995	4.5.1995
21	4.5.1995	10.5.1995

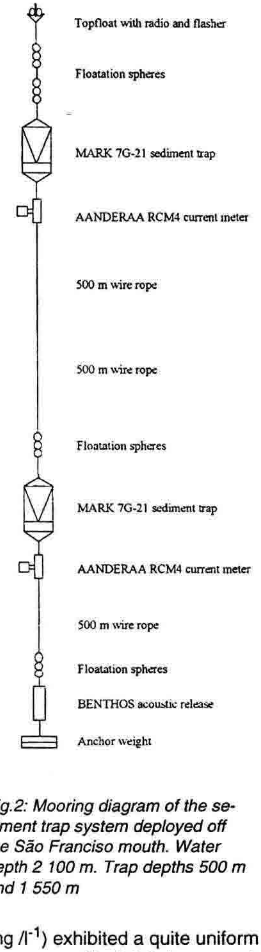

Fig.2: Mooring diagram of the sediment trap system deployed off the São Franciso mouth. Water depth 2 100 m. Trap depths 500 m and 1 550 m

The well oxygenated surface waters (mean dissolved oxygen 6.6 mg $/l^{-1}$) exhibited a quite uniform total alkalinity (ca. 2.15 mg $/l^{-1}$) and a mean pH of 8.2. In general, dissolved organic phosphorous (DOP) dominated over inorganic phosphorous (PO_4-P) except for the region between Cabralia and Porto Seguro (16°16' - 16°28'S) where high PO_4-P coincided with elevated dissolved silica contents (Fig. 3). Dissolved silica content, on average around 1 µmol*l^{-1}in the northern part of the investigated area, increased between Cabralia and Porto Seguro and south of the river Mucuri (Sta. 21; Fig. 3). Ammonia, with average concentrations >1 µmol/l^{-1}, was the dominant form of dissolved inorganic nitrogen. Chlorophyll (Chl) contents (Fig. 4) as well as Chl-c/Chl-a and Carotenoid/Chl-a ratios indicate that the phytoplankton community mainly consisted of diatoms, dinoflagellates and nanoflagellates in a senescent stage. In general, TSM content was < 2 mg/l^{-1} except for the region between rivers São Mateus and Doce (Stas. 22 - 26) where it increased up to 9.4 mg/l^{-1} (Fig. 5). Carbonate as well as organic carbon contents are highly variable (Fig. 5), whereas the C/N ratio and biogenic opal content are quite uniform. The very low TSM concentration and the high carbonate content suggest that resuspension of surface sediments is the major source of suspended matter in the Caravelas region (Stas. 16 - 19). The southward increasing TSM concentration combined with low C_{org} and carbonate contents indicates input of riverborne particulate matter dominated by lithogenics.

C_{org}, carbonate and opal contents of surface sediments are highly variable (Fig. 6). In general, C_{org} content is higher in front of mangrove outlets and near river mouths. It is < 1 % in the region between Cabralia and the river Mucuri (Stas. 12 - 21) where surface sediments are dominated by carbonate. Low carbonate contents in that region are probably due to the accumulation of fine-grained siliciclastic sediments in morphological depressions. South of the São Mateus (Sta. 22, 18°38'S) river input of terrigenous organic matter and nutrients and upwelling of cold and nutrient-rich water might be responsible for higher contents of C_{org} and biogenic opal in surface sediments.

A piston core was retrieved from 1 160 m water depth at 15°21'S, 38°36'W. The mean carbonate content of 60 % decreases rapidly to 25 % at 25 cm depth (Fig. 7). Then it decreases slowly downcore with several oscillations. Minimum content was observed at 120 cm depth (< 20 %). A rapid downward increase to > 50 % at 150 cm depth is followed by a similarly rapid decrease to < 20 % at 170 cm depth. Finally the maximum carbonate content of > 60 % was observed at 210 cm depth. A comparison of carbonate contents of core 9-PC and cores from the deep western Atlantic

Tab.2: List of stations occupied during JOPS-II-2a & b .CTD=CTD-probe; WS=water samples; CC=continous flow centrifuge; BG=box grab; PC=piston corer; STS=sediment trap system

Stat.No.	Latitude (S)	Longitude (W)	depth (m)	Date (UTC)	Time start (h)	Time end (h)	(UTC) gears
1	17°17.2'	38°29.0'	720	30.12.1994	22,45	0,17	CTD, WS, CC
2	14°50.1'	37°40.1'	>2000	31.12.1994	16,05	18,15	CTD, WS, CC
3	10°56.4'	36°13.4'	>2000	2.1.1995	10,06	12,38	STS deployed
4	10°48.9'	36°15.2'	980	2.1.1995	15,40	18,18	BG, PC
5	10°34.0'	36°22.3'	12	2.1.1995	20,05	23,00	CTD, WS, CC, BG
6	15°13.7'	38°58.4'	12	4.1.1995	8,21	11,02	CTD, WS, CC, BG
7	15°27.5'	38°55.0'	10	4.1.1995	12,30	15,30	CTD, WS, CC, BG, PC
8	15°41.6'	38°53.1'	10	4.1.1995	17,11	20,05	CTD, WS, CC, BG, PC
9	15°20.6'	38°35.8'	1160	5.1.1995	8,05	12,35	CTD, WS, BG, PC, PC
10	15°28.4'	38°41.5'	48	5.1.1995	14,00	16,52	CTD, WS, CC, BG
11	15°38.1'	38°50.0'	21	5.1.1995	18,10	21,15	CTD, WS, CC, BG
12	16°16.9'	38°59.3'	11	6.1.1995	8,09	11,04	CTD, WS, CC, BG
13	16°18.0'	38°57.5'	20	6.1.1995	11,22	13,20	CTD, WS, CC, BG
14	16°18.5'	38°52.0'	28	6.1.1995	14,56	15,37	CTD, WS, BG
15	16°27.8'	39°02.3'	10	6.1.1995	17,33	21,00	CTD, WS, CC, BG
16	17°37.5'	38°50.3'	24	7.1.1995	10,00	13,09	CTD, WS, CC, BG
17	17°39.0'	39°03.3'	10	7.1.1995	15,00	18,00	CTD, WS, CC, BG, PC
18	17°47.4'	39°06.7'	9	7.1.1995	19,02	21,40	CTD, WS, CC, BG
19	17°55.9'	39°01.7'	20	8.1.1995	9,59	12,43	CTD, WS, CC, BG
20	17°57.6'	39°18.1'	10	8.1.1995	15,00	17,28	CTD, WS, CC, BG
21	18°07.0'	39°30.9'	6	8.1.1995	19,18	21,38	CTD, WS, CC, BG
22	18°37.5'	39°42.5'	6	9.1.1995	10,00	12,01	CTD, WS, CC, BG
23	18°37.9'	39°42.2'	10	9.1.1995	12,18	12,21	BG
24	18°57.8'	39°42.9'	11	9.1.1995	14,15	16,16	CTD, WS, CC, BG
25	19°06.2'	39°41.9'	11	9.1.1995	17,14	18,43	CTD, WS, CC, BG
26	19°35.8'	39°45.0'	10	10.1.1995	8,02	9,32	CTD, WS, CC, BG
27	19°51.4'	40°02.7'	16	10.1.1995	11,51	13,14	CTD, WS, CC, BG
28	19°52.0'	40°02.8'	17	10.1.1995	13,55	14,00	BG
29	20°00.5'	39°40.0'	1030	10.1.1995	16,40	19,23	CTD, WS, BG, PC
1(leg 2b)	10°56.4'	36°13.4'	>2000	12.5.1995	8,00	16,00	STS recovered

(DAMUTH, 1975) suggest that 9-PC might cover a time span of approximately 25 000 - 30 000 years. The downcore distribution patterns of C_{org} and carbonate are nearly inverse (Fig. 7). Maximum C_{org} contents of > 1 % between 100 cm and 130 cm coincide with minimum carbonate contents suggesting that this core section might represent the last glacial maximum. At that time sea level was approximately 110 m lower than today (MARTIN et al., 1987) and mangroves as well as rivers could have exported carbon and associated elements directly on the continental slope. This and shelf erosion might have led to increased deposition of siliciclastic sediments and organic carbon during the last glacial maximum.

Acknowledgements

We gratefully acknowledge the support and assistance of Captains Klaassen and Priebe, the officers and crew of RV VICTOR HENSEN during the cruise.

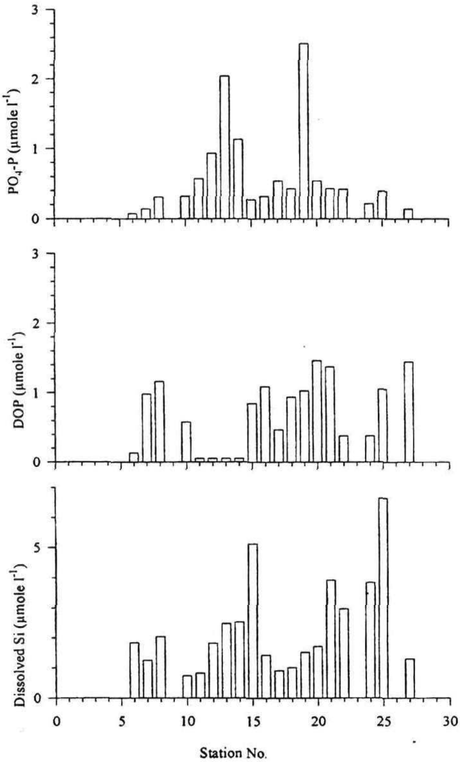

Fig. 3: a) Dissolved inorganic phosphorous (PO_4-P), b) dissolved organic phosphorous (DOP) and c) dissolved silica (Si) at stations sampled during JOPS-II leg 2

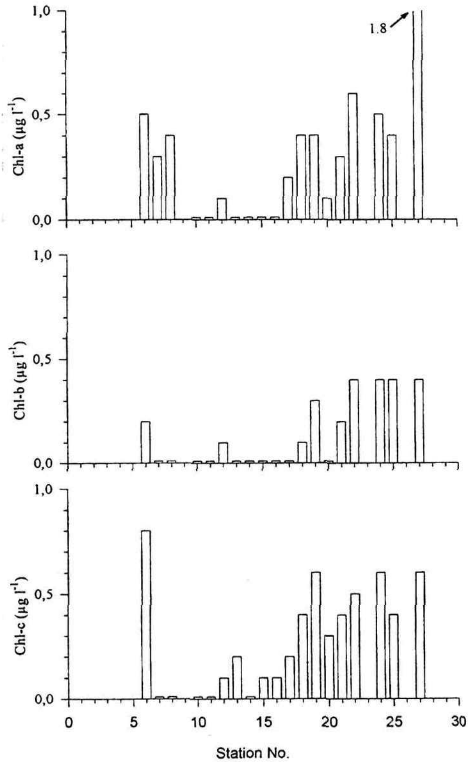

Fig. 4: a) Chlorophyll-a (Chl-a), b) chlorophyll-b (Chl-b) and c) chlorophyll-c (Chl-c) contents at stations sampled during JOPS-II leg 2.

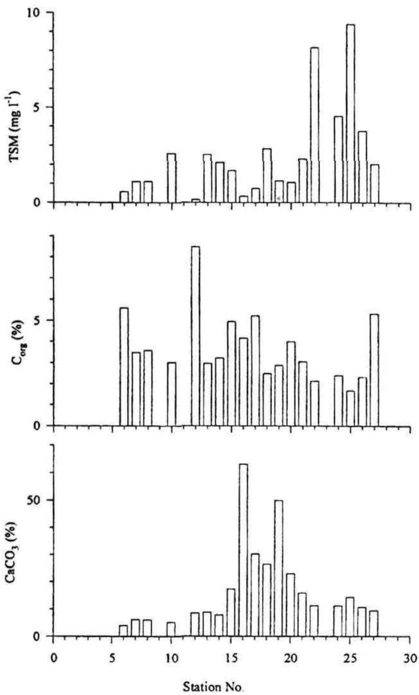

Fig. 5: a) Total suspended matter (TSM) content, b) C_{org} content of TSM and c) $CaCO_3$ content of TSM at stations sampled during JOPS-II leg 2

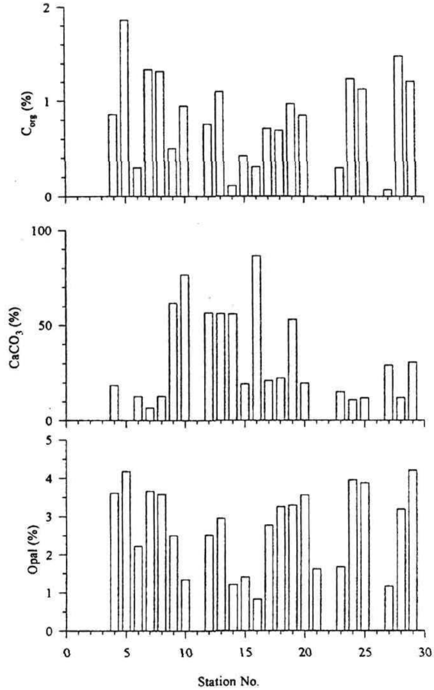

Fig. 6: a) C_{org}, b) $CaCO_3$ and c) opal contents of surface sediments at stations sampled during JOPS-II leg 2

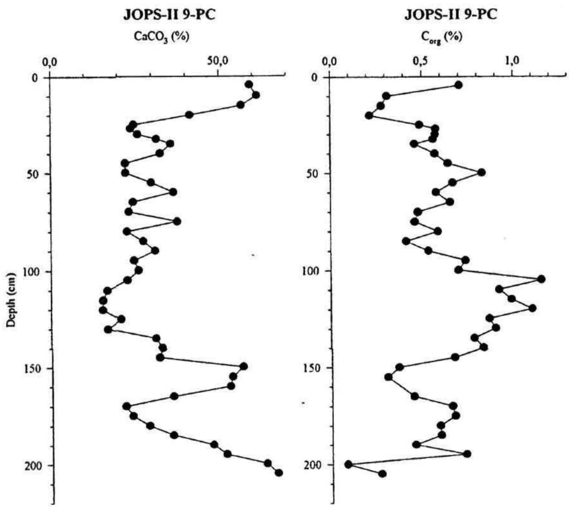

Fig. 7: a) $CaCO_3$ and b) C_{org} contents of core 9-PC obtained during JOPS-II leg 2.

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Leg 3: Transport mechanisms of biogeneous material, heavy metals and organic pollutants in east Brazilian waters,smale scale investigations

Chief scientists: Dr. M. Meyerhöfer (IfMK), Dr. E. Marone (CEM/UFPR)

Cruise report

Description of the area

The Abrolhos Bank is situated at the southern coast of the state of Bahia (Brazil, Fig. 1). It contains the largest coral reef of the Brazilian coast. The current system is dominated by the Brazil Current (parallel to the coast) and tidal pumping (perpendicular to the coast). Some small rivers -of which the Rio Caravelas is the most important- are responsible for the transport of terrigenous material to the coastal ecosystem. A characteristic feature of the river mouths are relatively large mangrove forests.

Objectives

The main objective of Leg 3 is the study of transport and sedimentation of biogenic matter in the Abrolhos Bank.

Tab. 1: Station position and activities during leg3 of JOPS II

Original st.no.	Ship st.no.	Date	Time	Latit. S	Longit. W	D [m]	Wind	Activities
20	1	14.1.1995	7:05	17 53.88	38 46.38	15	E2	Mooring ST Launch
20	2	14.1.1995	7:52	17 53.93	38 46.57	15	E2	Mooring CM Launch
20	3-8	14.1.1995	09:00-22:10	17 54.00	38 47.00	15	E2 to ENE 4	All
20	9-12	15.1.1995	02:17-14:05	17 53.96	38 46.33	16	ENE3 to N1-2	All
20	13	15.1.1995	16:13	17 53.96	38 46.33	16	NE3	Mooring ST Recov. & Launch
20	14	15.1.1995	18:30-18:40	17 54.30	38 46.70	16	NE3	CM
20	15	15.1.1995	19:00-19:40	17 56.00	38 45.30	14	ENE3	CM, All
10	16	16.1.1995	6:178	17 45.00	39 04.00	14	NNE4-5	All
12	17	16.1.1995	12:27-13:40	17 29.10	39 06.00	10	NE4	All
11	18	16.1.1995	14:39-15:55	17 38.10	39 03.50	14	NE4	All + Van Veen
9	19	16.1.1995	17:25-18:47	17 49.00	39 08.00	9	NE4-5	All + Van Veen
8	20	16.1.1995	19:23-20:05	17 53.00	39 11.00	9	NE5	All + Van Veen
20	21	17.1.1995	8:20	17 53.90	38 46.30	15	NNE4	Mooring ST Recov.
20	21	17.1.1995	8:47	17 54.00	38 46.50	16	NNE4	Mooring CM Recov.
20	22	17.1.1995	08:50-09:17	17 54.00	38 46.50	16	NNE4	All
21	23	17.1.1995	10:51-12:45	18 08.00	38 49.00	30	N4-5	All
19	24	17.1.1995	15:08-15:30	17 47.10	38 47.00	24	NNE4	Oceanography
18	25	17.1.1995	16:54-18:15	17 38.30	38 45.90	30	NNE4-5	All
17	26	17.1.1995	19:40-20:00	17 29.10	38 44.90	31	NNE4-5	Oceanography
10	27	18.1.1995	8:18	17 45.16	39 03.31	14	N5	Mooring ST Launch
10	28	18.1.1995	8:34	17 45.34	39 03.36	14	N5	Mooring CM Launch
10	29	18.1.1995	10:10	17 45.10	39 03.60	12	N5	All
10	30	19.1.1995	Whole day	17 44.60	39 04.80	10	NE3	All
10	31	20.1.1995	06:45-06:55	17 45.00	39 03.00	15	NE3-4	Mooring ST + CM Recov.
12	32	20.1.1995	08:38-08:45	17 29.00	39 06.00	13	NNE4	Van Veen
13	33	20.1.1995	09:42-10:46	17 20.00	39 07.00	13	N3	All + Van Veen
16	34	20.1.1995	13:22-15:00	17 20.10	38 40.00	25	NNE3-4	All + Van Veen
30	35	20.1.1995	16:45-17:40	17 29.10	38 24.10	42	NNE4	All

Abbreviations: ST: Sediment Trap; CM: Current Meter; All: CM, STD, Fluorescence, Plankton Nets, Water Bottles ; Oceanography: CM, STD, Fluorescence

Activities

During this Leg, 28 stations were executed, measuring fluorescence, temperature, salinity and current profiles. Two current meter and sediment trap moorings, six Van Veen bottom samples, 48 water samples for seston, organic carbon/nitrogen/phosphorus, inorganic nutrients, chlorophyll, pigment specification and phytoplankton standing stock were collected. Fifty vertical and horizontal net hauls for zooplankton species composition, abundance, biomass and for fecal pellet density in the water column were executed. Additionally 10 net hauls were made for collecting zooplanktonic organisms that were used in fecal pellet and ingestion experiments and for HPLC pigment analysis on individual species.

RV Victor Hensen left the port of Vit"ria on 13.01.1995, after a slight delay due to difficulties with getting fuel from the supply ship. On 14.01.1995, at7:00 am, station work begun at the fixed station (St. 20, see station list) within the Abrolhos Channel. Appropriate weather was encountered and sediment trap and current meter moorings and continuous ingestion and fecal pellet production experiments were executed. Cross sectional current and STD stations were made during one tidal cycle to observe lateral inhomogenities. The moorings were installed during 72 hours at this point and then reinstalled at the central station of the Sueste Channel (St. 10), for additional 46 hours, to

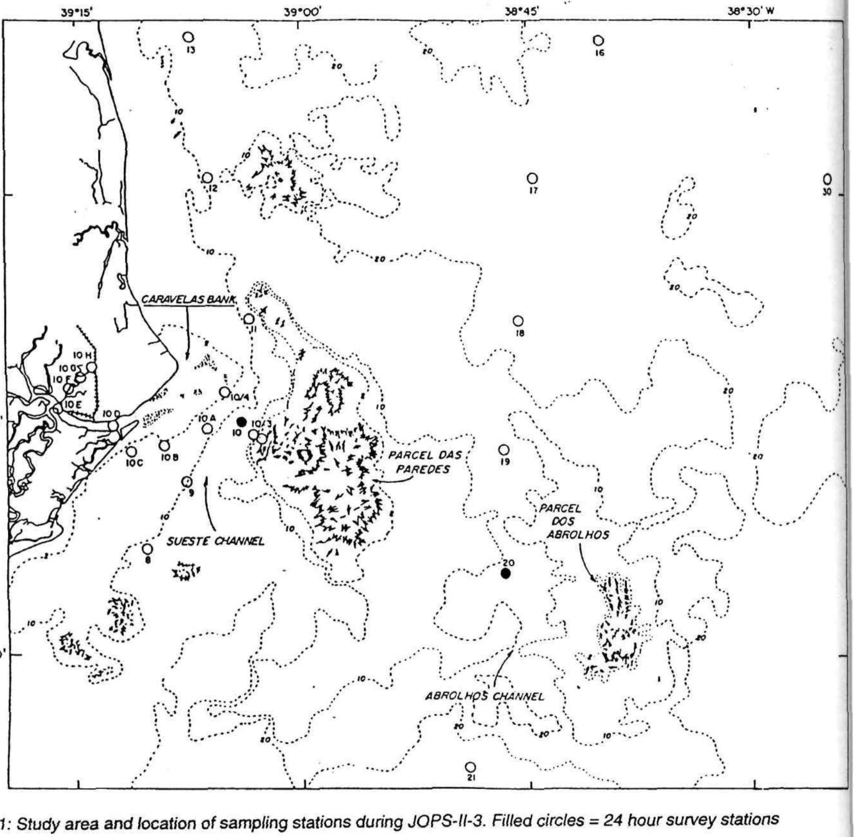

Fig. 1: Study area and location of sampling stations during JOPS-II-3. Filled circles = 24 hour survey stations

obtain more accurate measurements of the estuarine plume observed during the cruise coming from the Caravelas coastal system. At this station, lateral current and TS profiles were executed during one tidal cycle.

Two north to south transects, one in the Abrolhos Channel and the other in the Sueste Channel, with a total of 11 stations were sampled for the parameters and variables mentioned above. One oceanic station (St. 30) was also sampled. The originally planned oceanic transect was left out. Instead more emphasis was placed on the short term dynamics of material transport in both the Abrolhos and Sueste Channels. Station positions and activities are given in Table 1.

Main results

Physical oceanography
E. Marone (UFPR), R. de Camargo (UFPR)

Figure 2 shows the T/S relationship of all 28 stations. These data correspond mainly with the waters of the Brazil Current. Considering the salinity gradient of the River Caravelas, none of the data pairs showed characteristics of coastal water.

The observed profiles of salinity, temperature and sigmaT were normally homogeneous during all the cruise (Fig. 3a). In some cases (Fig. 3b) a small vertical gradient was observed, mainly due to solar heating of surface waters. These small gradient disappeared quickly with the surface cooling and/or increasing currents.

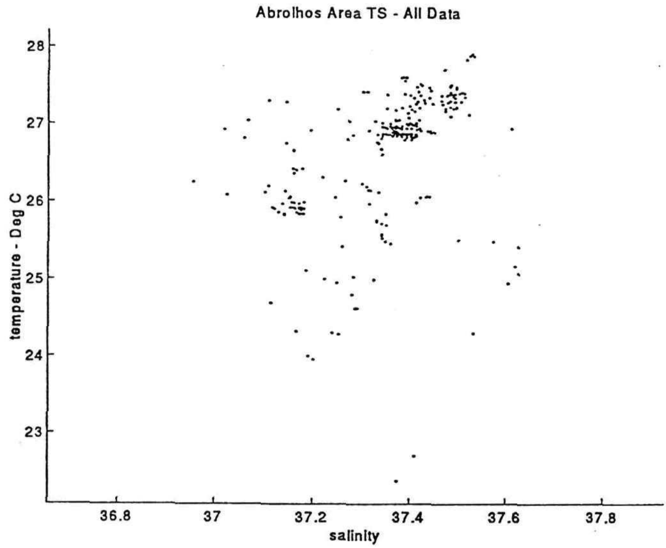

Fig. 2 : T/S relationship of grid stations

Fig. 4a shows the vectors (velocity and direction) of the currents at the surface and bottom, obtained from the continuous measurements (24hs) at the mooring in the Abrolhos Channel (station 20, Fig. 1). At the surface, the average velocity was 19 cm/s with a predominant direction of 197x, which corresponds with the direction of the channel. Average velocity at the bottom was 13,1 cm/s with the main direction of 200x. Calculation of the Neumann index shows, that 30% of the movement is not permanent, indicating the relative importance of the tides at this site.

Fig. 4b indicates the north-south and east-west components of the currents at the surface and the bottom of the Abrolhos Channel. In the N-S direction (curve "r") one can see the component of the Brazil Current with interferences of the tides. The E-W component (curve "b") on the other hand, with velocities up to 20 cm/s, was extremely marked and showed the importance of the tides for a possible exchange of material between the Parcel das Paredes and the Parcel dos Abrolhos.

In the case of the Sueste (Caravelas) Channel (station 10, Fig. 1), near the coast, surface and bottom currents also showed principal movement along the channel but with much higher velocities (Fig. 5a). The E-W components of surface and bottom circulation (Fig. 5b, curve "b") on the other hand were around zero at this site. This means, that the strong currents parallel to the coast (Fig. 5b, curve "r") formed a type of hydrodynamical barrier which perhaps *inhibited the transport of estuarine material to* the inner parts of the reef system. An additional barrier is the reef system of the Parcel das Paredes, which runs parallel to the coast. If there is any import of coastal material, it must originate from the sand-banks in the north.

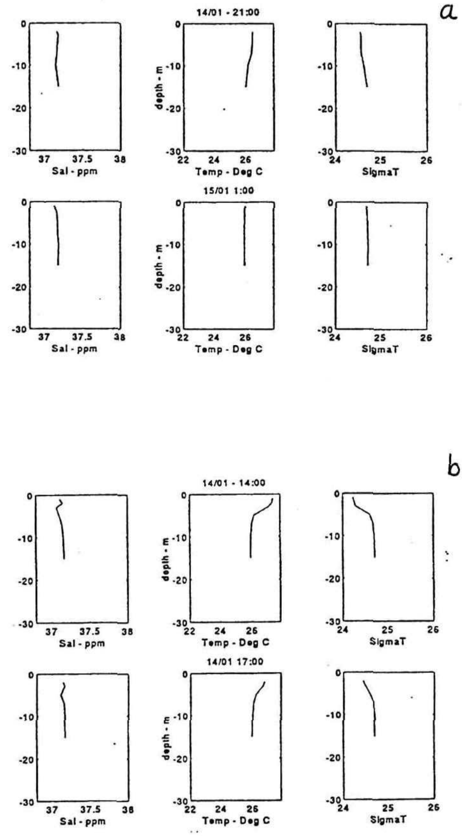

Fig. 3: Examples of vertical profiles of salinity, temperature and density

Suspended matter
T. Leipe (IOW)

Suspended particulate matter (SPM) was *analyzed by means of scanning electron* microscopy and microprobe analysis. The aim was to characterize the mineralogical composition and chemical classification of SPM. Fig. 6 shows these characteristics on a transect from the inner River Caravelas to the open ocean. Obvious was the strong influence of carbonates near the reef. Detritic carbonates dominated near the coast, while carbonate shells of planctonic organisms occurred more in the reef waters and the open ocean. Biogenic silica (opal) was common in the river and the reef area. The main forms of silica particles were centric diatoms in the estuary and needle shaped in the reef waters. Resistant organic matter from land or from zooplankton (e.g. crustaceae) were mainly found in the river and the open ocean. Clay minerals were characterized by iron containing smectite and kaolinite with pseudohexagonal shape. These two minerals were mainly found in the near shore area. Iron rich chlorite occurred especially in the river and the open sea.

Particulate Organic Matter and Nutrients
B. Knoppers (UFF)

Between the coast and the Abrolhos Bank were sampled 28 stations for the analysis of nitrate, nitrite, ammonia, orthophosphate, silicate, suspended matter (seston), particulate organic carbon (POC) and nitrogen (PON), and Chlorophyll-a. An additional transect was executed from the Sueste Channel (between the coast and the Parcel dos Paredes) to the inner mangrove system of the River Caravelas (see Fig. 1).

In general, nutrient concentrations were extremely low, except for a marked increase within the mangrove creek. Seston, POC, PON and Chlorophyll-a exhibited low concentrations throughout, *except for the Caravelas sand bank and the mangrove waters (Fig. 7a-c).The results show, that in* spite of higher concentrations of these variables within the river system, the input into the reef system is very low. This was due to the extreme low fresh water input and the retainance in the mangroves. The low orthophospate and silicate concentrations and the general trend towards phosphate limitation (Fig. 7d) of primary production are probably related to the nature of the carbonaceous environment and also to the presence of the oligotrophic waters of the Brazil Current. The impact of reef metabolism and material export to the Abrolhos Channel was suggested by the medium ammonia levels in the water column, probably as a result of biological decomposition of organic material within the reefs, net respiration of the water column and the presence of carbonaceous particles in the sediment trap samples of the Abrolhos Channel.

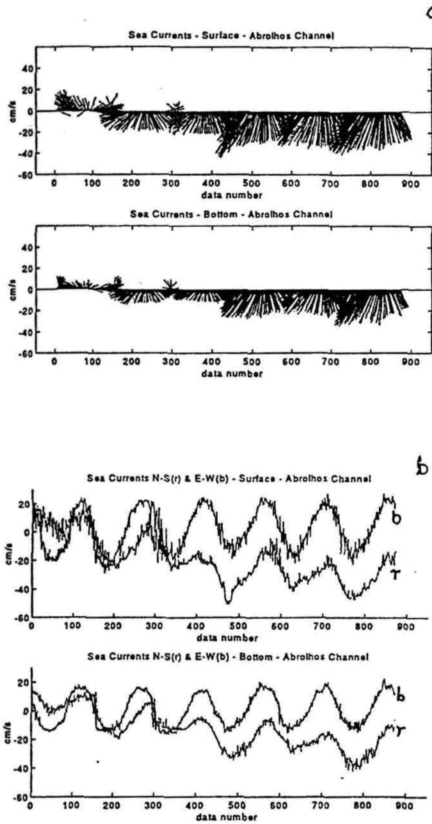

Fig. 4: Continuous current measurements at station 20 (Abrolhos Channel)

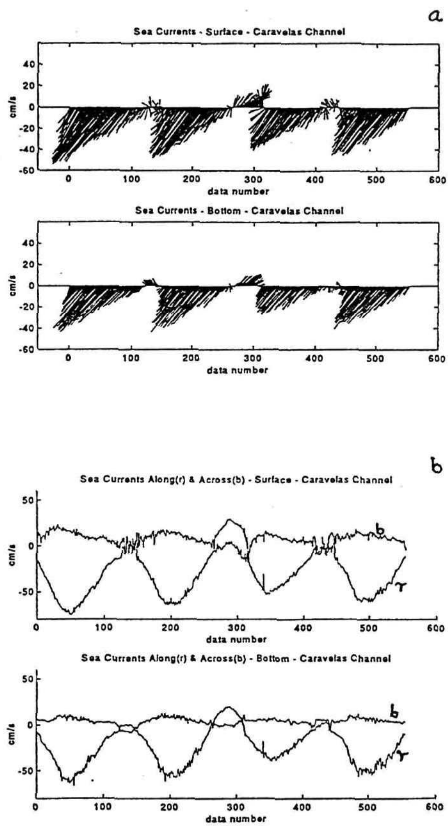

Fig. 5: Continuous current measurements at station 10 (Sueste or Caravelas Channel)

Phytoplankton
M. Meyerhöfer (IfMK)

Fig. 8a shows this fractionation for surface Chlorophyll-a at three stations. The farer away from the coastal station 10, the higher is the importance of the smallest phytoplankton, a sign for increasing oligotrophy. This is corroborated by the analysis of the taxonomic Pigments. The carotenoid Fucoxanthin (FUCO, Fig. 8b) stands for eucaryotic algae like Diatoms, Chryso- and

Prymnesiophytes. The ratio of Fucoxanthin to Chlorophyll-a indicates the relative contribution of these groups to the total community. This ratio showed a strong gradient from the mangrove system (a great part of the population is formed by the groups mentioned above) to the open ocean (only a small part of Chlorophyll stems from eucaryotic algae).

Very small procaryotic algae like Cyanobacteria and Prochlorophytes showed an inverse trend, which can be detected by means of the pigment Zeaxanthin (ZEAX, Fig. 8c). This means, that every region of the Abrolhos ecosystem has it's distinct phytoplankton population with clear evidence of oligotrophy in the outer regions.

Zooplankton

R. Lopes (UFPR), J. Dutz (AWI)

The determination of the zooplankton standing stock was combined with ingestion, gut pigment specification and faecal pellet production measurements. Additionally, net samples were taken to determine the concentration of faecal material in the water column.

All zooplankton taxa identified in the Abrolhos area were either associated with the tropical waters of the Brazil Current or occur both in tropical and shelf waters (Tab. 2). Few coastal species and none of the species belonging to the South Atlantic Central Water association were observed. The highest species diversity and the lowest zooplankton abundance occurred in the northern sector of the study area, especially in the outer station 16. Several species belonging to the Brazil Current system were restricted to this area. The copepods were the most diversified and abundant group, with 47 identified species comprising between 34 to 72% of the total zooplankton abundance (mean: 58%). The dominant copepods were Paracalanus quasimodo, Temora stylifera and Coryacaeus giesbrechti. Total zooplankton abundance ranged from about 700 to 1900 Ind./m3 at the grid stations (Fig. 9). Large temporal shifts in zooplankton abundance occurred at the fixed stations of Sueste and Abrolhos Channels.

The distribution of zoooplankton bioass showed differences between he inner und outer pats of the shelf (Fig. 10). Samples

Tab. 2: List of zooplankton taxa a) Brazil Current species (b)Oceanic + shelf water species (c)Coastal species, occurring at low densities

Holoplankton	Hydromedusae (n. id.)
Copepoda	Acoela
Nannocalanus minor (a)	Nematoda
Undinula vulgaris (a)	Pteropoda
Acrocalanus longicornis (a)	*Creseis acicula (b)*
Paracalanus aculeatus (a)	*Limacina spp (b)*
P. indicus (b)	Decapoda
P. parvus (a)	*Lucifer faxoni (b)*
P. quasimodo (b)	Amphipoda
Paracalanus sp A	Isopoda (Epicaridea)
Clausocalanus furcatus (b)	Ostracoda
C. mastigophorus (a)	*Conchoecia spA (b)*
C. paululus (a)	Cladocera
Ctenocalanus sp A (juv.)	*Evadne tergestina (b)*
Calocalanus pavo (a)	Cumacea
C. contractust a)	Chaetognatha
Mecynocera clausi (a)	*Sagitta enflata (b)*
Eucalanus pileatus (b)	*S. friderici (b)*
Euchaeta marina (a)	*S. hispida (b)*
Temora stylifera (b)	*S. minima (b)*
Scolecithrix danae (a)	*S. serratodentata (b)*
Candacia bipinnata (a)	Appendicularia
Pleuromamma abdominalis (a)	*Oikopleura dioica (b)*
Calanopia americana (b)	*O. longicauda (b)*
Labidocera acutifrons (a)	*O. rufescens*
Pontellopsis brevis (b)	*Fritillaria spp (b)*
Centropages veldficatus (b)	Thaliacea
Acartia danae (a)	*Thalia dezocratica (b)*
Oithona nana (b)	*Doliolum nationalis (b)*
O. plumi£era (c)	
O. setigera (a)	**Meroplankton**
Oncaea curta (b)	
O. media (b)	Polychaeta
O. venusta (b)	Bivalvia
Corycaeus amazonicus (c)	Gastropoda
C. giesbrechti (b)	Cirripedia
C. speciosus (a)	Decapoda
Farranula gracilis (a)	Bryozoa
Copilia mitiabilis (a)	Echinodermata
Sapphirina ovatolanceolata	Fish eggs and larvae
Poecilostomatoida sp A	
Microsetella sp A	
Macrosetella gracilis (a)	
Euterpina acutifrons (+)	
Clytennestra rostrata (a)	
Harpacticoida sp A, B and C	
Monstrilloida sp A	
Acantharia	
Foraminifera	
Siphonophora	
Bassda bassensis (a)	
Muggiaea kochi (+)	
Diphyes bojani (b)	
Agalma elegans (a)	

Tab. 3: Phytoplankton standing stock, zooplankton ingestion and faecal pellet production rates in terms of carbon

	Caravelas Channel Stations 8, 10	Abrolhos Channel Station 20
Phytoplankton (Chl a µ/l)	0,476	0,151
Phytoplankton (µg C/l)	23,8	7,55
Σ Ingestion (µg C/h)	1,64	0,65
in % Phytoplankton-C	6,9	8,5
Σ Faeces-Production (Ng C/h)	0,51	0,46
in % Phytoplankton-C	2,1	6,1

collected at the inner stations 8,10 and 12 were characterized by only small and mid-sized organisms; the latter contributed more than 70% of total biomass on average, which varied between 8,4 and 18,8 mg DW/m3. In contrast, on the outer parts of the shelf (stations 16,18,20 and 21) and in the north of the study area (station 13) organisms of each size fraction were present. The total biomass was slightly lower than on the inner shelf and varied between 4,7 and 15,5 mg DW/m3.

The results of the ingestion experiments performed on stations 8,10 and 20 showed clear differences between inner and outer parts of the shelf (Fig. 11) Near the coast (stations 8 and 10) ingestions rates of the organisms of both size fractions were comparable. On the outer shelf the rates were lower, but again comparable between the three size fractions. Therefore the total amount ingested by zooplankton on the outer shelf was only 60% of the Chlorophyll-a ingested by exclusively two zooplankton size fractions near the coast.

The intense transport of zooplankton by the prevailing north-south currents might explain the dominance of shelf and oceanic species associated with the Brazil Current. In addition, the almost entire absence of "true" coastal species was probably connected to the weak input of estuarine and coastal waters into Sueste Channel. The results of eight experiments to determine ingestion and faecal pellet production were converted to community rates in terms of carbon and related to the calculated phytoplankton carbon (Tab. 3). This conversion shows that despite a two-fold difference in the absolute amount ingested by the zooplankton in the Sueste Channel in comparison to the Abrolhos Channel, the grazing pressure on the standing stock of phytoplankton and the faecal pellet production rates were about the same in both ares. However in term of phytoplankton carbon, the zooplankton of the Abrolhos Channel excreted a three-fold higher amount than in the Sueste Channel. This suggests that other food sources like microzooplankton and detritus were an important component of the diet of the mesozoolankton on the outer shelf.

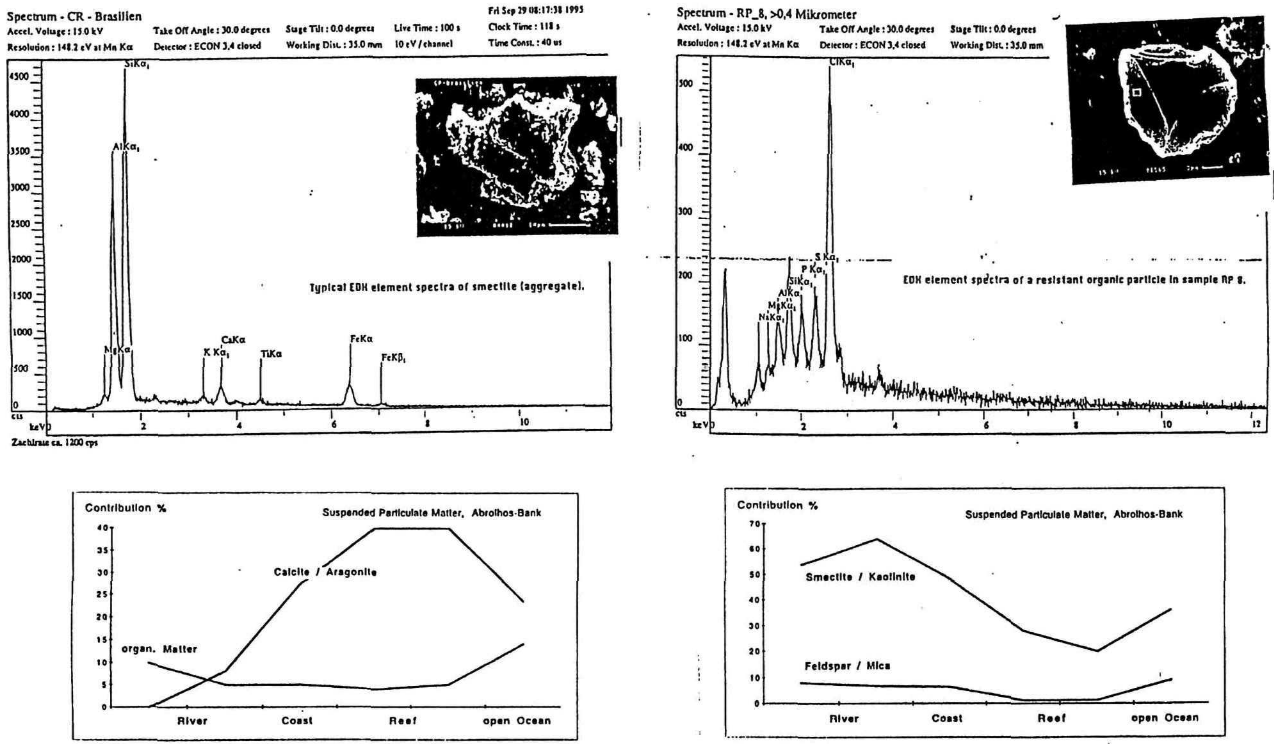

Fig. 6: Mineralogical and chemical characterization of suspended particulate matter

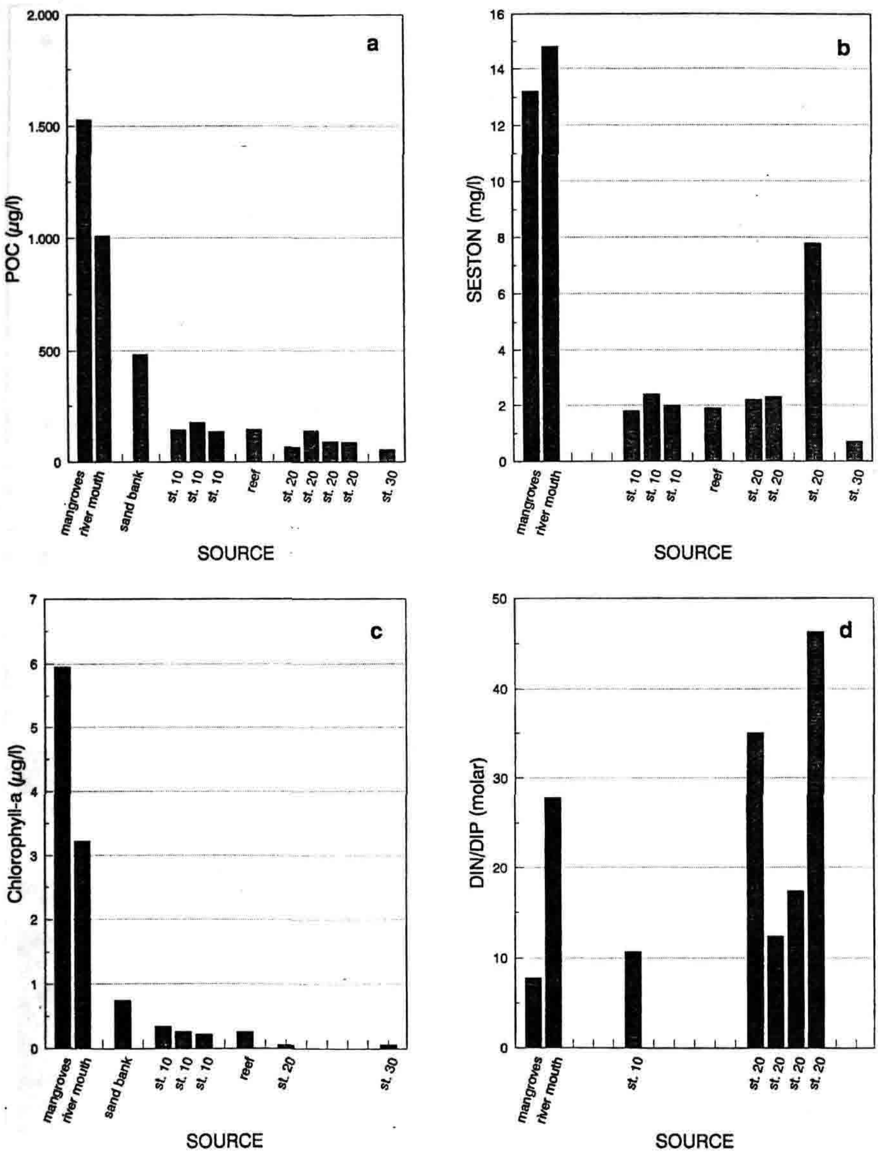

Fig. 7: Distribution of suspended matter and nutrients on a transect from the inner mangroves to the open ocean; a: POC, b: Seston, c. Chlorophyll-a, d: ration of dissolved inorganic N to phosphate

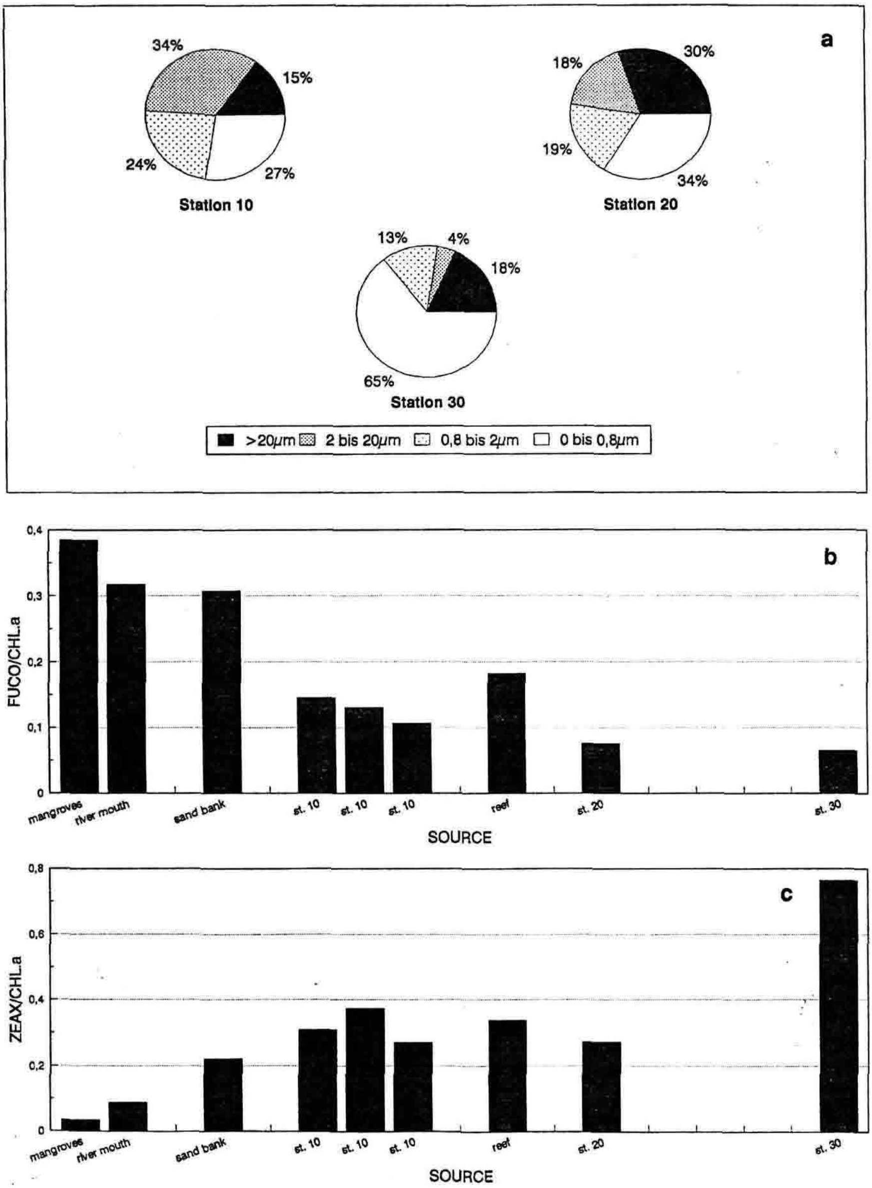

Fig. 8: a: size fractionation of Chlorophyll-a. Ration of Fucoxanthin (b) and Zeaxanthin (c) to Chlorophyll-a on a transect from the inner mangroves to the open ocean

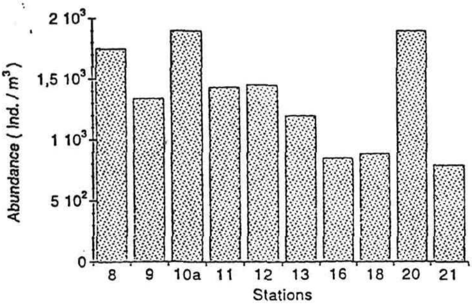

Fig. 9: Distribution of total zooplanktion (Ind./m^3) at a grid stations

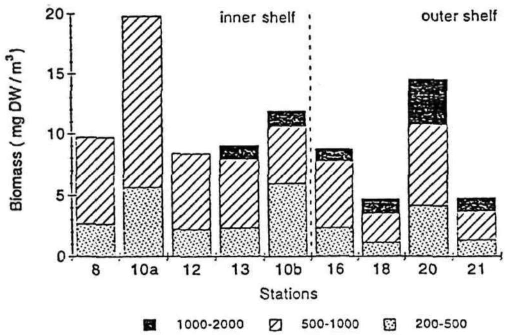

Fig. 10: Distribution of the biomass (mg dry weight (DW/) of thraee zooplankton size fractions (200-500, 500-1000 and 1000-2000 μm) at grid stations

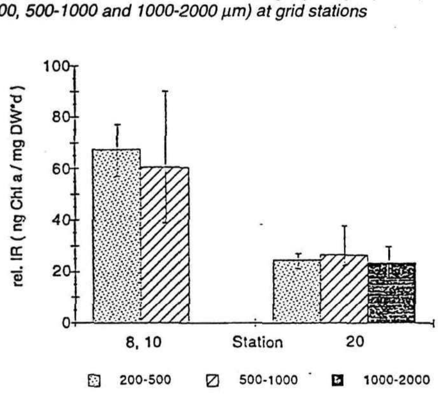

*Fig. 11: Mean daily relative chlorophyll-a ingestion rates (IR, ng Chl-a/mg DW*d) of three zooplankton size fractions at stations 10 and 20. Vertical lines represent ranges of values*

Leg 4: Analysis of small scale patterns in distribution, productivity and dynamics of phyto-, microzoo- and macrozooplankton in the area of oceanic banks, islands and rocks off Northeast Brazil

Chief scientists: B. Ueberschär (IfMK), R. Lessa (UFRPE)

Cruise report and first results

Introduction

In context with the research activities of RV "Victor Hensen" in oceanic areas off Brazil the objective of leg 4 was to investigate some aspects of the biology of seamounts and oceanic islands off the Brazilian coast, including the São Peter/São Paul Rocks (leg 4a), around Fernando de Noronha and adjacent areas (Atol das Rocas, adjacent seamounts and on the Sirius and Guara Bank, leg 4b) and the area of the Northern chain (Cadeia Norte Brasileira, leg 4c).

The concentration of commercially valuable fish species around seamounts and oceanic islands is well documented. It has been suggested, that this is due to increased densities of prey organisms around islands and over seamounts (micro- and macroplankton) which in turn are caused by enhanced primary productivity due to topographic effects on local hydrographic conditions (jets, eddies, upwelling). In oligotrophic waters, it has been suggested that uplifting of isothermes into the euphotic zone (upwelling) can introduce biogenic material into nutrient-poor water and can cause an increase in primary production. Evidence for enhanced primary productivity over seamounts resulting in increased concentrations of zooplankton and fish is, however, sparse.

This project was conducted to investigate some aspects of the hypothesis about enhanced primary productivity over seamounts and around oceanic islands and the consequences for the dynamics and biodiversity of plankton communities. Fig.1 shows the araes off Brazil where the research grids were located during leg 4.

Research activities during the cruise with "Victor Hensen" along the seamounts and oceanic islands yielded a set of samples of phyto,- mikro,- makro,- and ichthyoplankton and nutrients as well as some samples of seamount benthos. Regular monitoring of abiotic data (CTD-profiles, occasionally current meter measurements) completed the biological samples.

This report summarises the research activities from leg 4, details for each subleg (4a, 4b and 4c) are given in the following sections. Any numbering etc. of samples from leg 4 should refer to this report.

Material and Methods

Equipment used and sampling procedures

The following equipment was launched in chronological order of appearance:

1. Secchi-Disk
2. Fluorescence-Probe (maximum depth 45m)
3. CTD + stratified water sampling (NISKIN-Bottles)
4. APSTEIN-net, 100µm (leg 4a) and 20µm (leg 4b + 4c)
5. Stratified BONGO-net samples, 300µm + 500µm (150, 100, 50m)
6. NEUSTON-net (500µm + 500µm)
7. Current-meter, profiles on selecd stations only.
8. VAN VEEN-Sampler (benthos samples) on selected stations during leg 4b+c

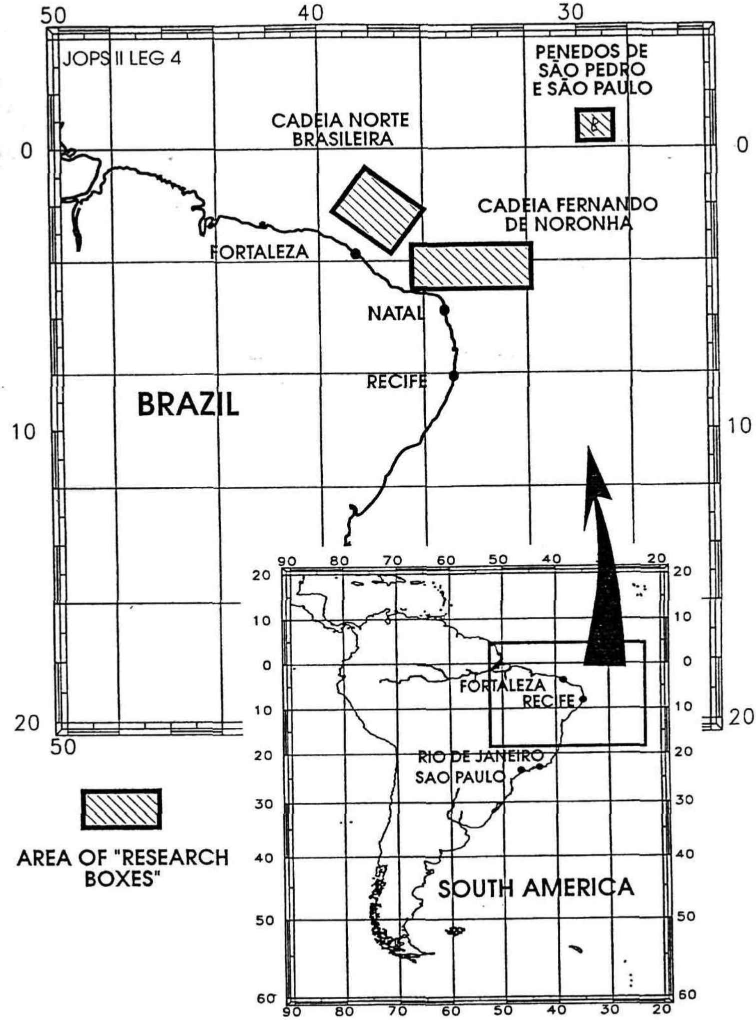

Fig. 1: A synoptic view of the research area off Northeast Brazil where samples were taken during JOPSII leg 4 is shown. The stations are marked with "boxes" for each leg.

Using a CTD (ME-type), vertical profiles of temperature, salinity, oxygen, pH and density were monitored by using ME Multipar Version 4.0 for each station (depth according to bottom topography, maximum depth 400m). Data files are available in *.MER and ASCII-format.

Water samples were taken by using NISKIN-Bottles attached to a CTD device. 1-2l of water from each depth (within the uppermost 100m of the water column) were fractionated by filtration: <20µm, <2.0µm, <0.8µm in order to measure POC, PON, and chlorophyll a and pigments for HPLC. Gross-oxygen-production was measured in simulated in situ experiments with water from the morning stations.

The APSTEIN net was launched regularly down to a depth of 100m, except on shallow positions over seamounts, samples were preserved in Formaldehyd (4% solution).

BONGO-net samples were taken as stratified double oblique hauls in the order 50m, 100m, and 150m, towing speed was about 3 knots. The hauls from 50m and 150m were preserved completely in Formaldehyde (4% solution, leg 4a) or partially sorted (leg 4b +4c). The 100m haul (both nets) were immediately sorted for fish larvae and cephalopods, remaining samples were preserved in Formaldehyde 4% solution). The sorted fish larvae and cephalopods were transfererred into Eppendorf-caps (10 to 15 individuals each) and stored in a deep freezer (-74°C).

NEUSTON hauls were preserved completely in Formaldehyde (4% solution). Current-meter profiles were measured on selected stations close to São Pedro/São Paulo Rocks (leg 4a).

Benthos samples were taken during leg 4b and 4c at shallow positions over seamounts (250 m). Samples were sorted immediately for makrofauna and preserved in Formaldehyde (4% solution).

Tab. 1: List of stations Sao Pedro/Sao Paulo, leg 4a 28.01.94-04.02.95

Stat.No. Logbook	Stat.No. JOPS II	date	time	position N	position W	depth	wind	equipment launched
37	4	28.1.	6:04	00°49,1	029°34,0	>2000	SE 3/5	SD,CTD,FL,AN,BO,NN
38	3	28.1.	10:29	00°42,1	029°40,0	>2000	ENE 4/6	SD,CTD,FL,AN,BO,NN
39	2	28.1.	14:58	00°32,0	029°52,0	>2000	E 3	CTD,FL,AN,BO,NN
40	1	28.1.	18:24	00°24,0	030°00,0	<2000	E 2/3	SD,CTD,FL,AN,BO,NN
41	5	29.1.	6:00	00°56,0	029°20,2	900	NE 3	SD,CTD,FL,AN,BO,NN
42	6	29.1.	12:45	01°19,0	029°06,0	>2000	NE 3	CTD,FL,AN,BO,NN
43	7	29.1.	16:35	01°36,0	028°57,0	>2000	NE 3	CTD,FL,AN,BO,NN
44	20	30.1.	6:00	00°55,5	029°19,5	240	ENE 3	SD,CTD,FL,AN,BO,NN
45	21	30.1.	10:18	00°57,0	029°08,0	>2000	ENE 3	SD,CTD,FL,AN,BO,NN
46	22	30.1.	13:15	00°57,0	028°55,0	>2000	ENE 3	CTD,FL,BO,NN
47	23	30.1.	16:02	00°57,2	028°42,0	>2000	ENE 3	CTD,FL,BO,NN
48	22/2	30.1.	19:52	00°57,0	028°55,0	>2000	ENE 3	CTD,FL
49	30	31.1.	6:00	00°44,0	029°10,0	>2000	ENE 3	SD,CTD,FL,AN,BO,NN
50	29	31.1.	10:12	00°50,0	029°21,0	>2000	ENE 3	SD,CTD,FL,AN,BO,NN
51	28	31.1.	12:40	00°54,1	029°20,0	70-1000	E 3	CTD,FL,AN,BO,NN
52	24	1.2.	6:00	01°10,5	029°35,5	>2000	E 3	SD,CTD,FL,AN,BO,NN
53	25	1.2.	9:37	01°05,5	029°31,0	>2000	ENE 2	SD,CTD,FL,AN,BO,NN
54	26	1.2.	121:20	01°00,0	029°21,0	>2000	E 2	CTD,FL,AN,BO,NN
55	19	1.2.	15:26	00°55,0	029°21,5	500-1000	E 2	CTD,FL,AN,BO,NN
56	19	2.2.	6:00	00°55,2	029°21,6	>2000	E 2	SD,CTD,FL,AN,BO,NN
57	18	2.2.	11:04	00°55,2	029°26,3	>2000	Calm	SD,CTD,FL,AN,BO,NN
58	17	2.2.	13:45	00°57,0	029°35,5	>2000	Calm	CTD,FL,BO,NN
59	16	2.2.	16:58	00°57,0	029°43,6	>2000	Calm	CTD,FL,AN,BO,NN
60	11	3.2.	6:00	00°56,0	029°21,0	>2000	ENE 2	SD,CTD,FL,AN,BO,NN
61	12	3.2.	9:44	01°03,0	029°21,0	>2000	NNE 2	CTD,FL,AN,BO,NN
62	13	3.2.	12:25	01°10,0	029°21,0	>2000	NNE 2	CTD,FL,AN,BO,NN
63	11	3.2.	16:06	00°54,0	029°21,0			CM
64	20	3.2.	17:10	00°55,5	029°19,5			CM
65	10	3.2.	18:43	00°54,4	029°21,0			CM
66	19	3.2.	19:46	00°55,0	029°21,5			CM
67	10	4.2.	6:00	00°54,0	029°21,0	>2000	Rain	SD,CTD,FL,AN,BO,NN
68	9	4.2.	9:55	00°46,0	029°21,0	>2000	Rain	CTD,FL,AN,BO,NN
69	8	4.2.	12:30	00°38,9	029°20,9	>2000	Rain	CTD,FL,AN,BO,NN

SD: SECCHI-DISK
CTD: HYDROGRAPHY + NISKIN-BOTTLES
FL: FLUORESCENCE PROBE
AN. APSTEIN-NET
NN: NEUSTON-NET
CM: CURRENT METER
VV: VAN-VEEN SAMPLER
BO: BONGO-NET

A. Leg 4A, São Pedro/São Paulo Rocks (25.01.-07.02.1995)

RV "Victor Hensen" left Recife at noon on 25.01.95 and arrived at São Pedro/São Paulo rocks in the morning of 27.01.95. Before arrival, the complete set of equipment was launched at a test-station (i.e. St. 1, Fig. 2). Due to mechanical problems, the MOCNESS system was not used on leg 4a and occasionally, the NISKIN bottles attached to the CTD malfunctioned. A total of 29 stations were sampled betweeen 28..01.-04.02.95. Current meter measurements were performed at 4 additional stations. On 07.02.95 RV "Victor Hensen" arived at the harbour of Natal.

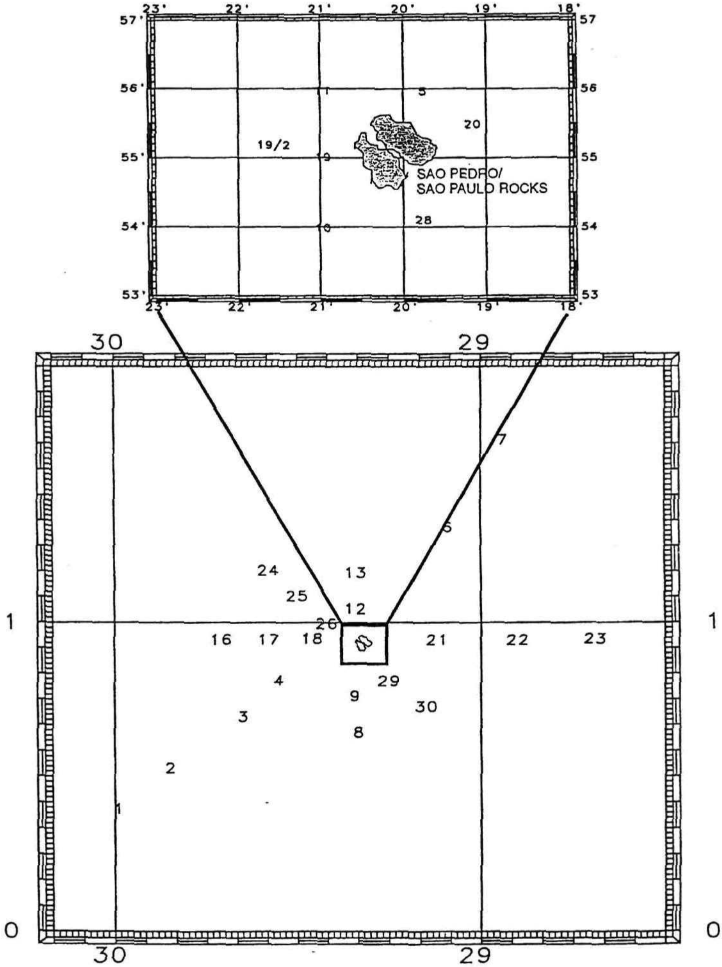

Fig. 2: The station numbers and their locations for leg 4a are given. The closest area around the São Peter/São Paulo Rocks is zoomed in for better resolution. Stations with CTD casts and current -meter measurements only are not shown

Hydrography
P. Hazin (UFRPE) & P. Travassos (UFRPE)

Temperature, salinity and oxygen profiles were obtained at all stations with a CTD. Maximum launching depth was 400 m. Parallel water samples at five depths up to 100 m were taken for measurements of dissolved oxygen on board in order to calibrate the oxygen probe.

Nutrients, suspended matter, phyto- and microzooplankton
K. von Broeckel (IfMK), N. Lins da Silva (UFPE), M. Meyerhoefer (IfMK) & P. Travassos (UFRPE)

At all 29 stations in Situ fluorescence profiles up to 45 m depth were performed. Water samples were taken at 5 depths up to 100 m for analysis of dissolved oxygen, dissolved inorganic nutrients, particulate organic carbon (POC) and nitrogen (PON), chlorophyll a, and phyto- and microzooplankton species composition and biomass. Particulates were retained on Whatman GF/F filters and frozen on board prior to futher processing. The filtrate was frozen for further nutrient analyses. Zooplankton samples for size class and biomasss determinations were taken with an Apstein net (100 µm mesh size) from the upper 100 m of the watercolumn.

On 6 stations close to the Rocks and on 2 oceanic stations, water samles were taken in the morning hours for the measurement of primary porduction by the oxygen simulated in Situ incubation method, for size fractioned filtration (total, < 20 µm, < 2,0 µm and < 0,8 µm), and pigment speciation in all size frations by HPLC analyses. Irradiance depths (100%, 30%, 1% and 0,1%) were estimated by Secchi disc readings.

First results were summarized as follows:

- the thermocline which starts in about 30 to 60 m, depending on the distance of the station from the Rocks, is normally coupled with a chlorophyll-maximum.

- with the rising thermocline (see CTD-results) around and close to the Rocks, the chlorophyll-maximum and thus the amount of phytoplankton cells increases.

- most phytoplankton cells within the chlorophyll maximum seem to be in the 2 size classes of <0.8µm and 0.8-2.0µm, which means, that eventually the cyanophyte Synechococcus spp. and prochlorophytes are the main primary producers.

- oxygen-production measurements show no detectable oxygen production at the "oceanic" stations.

- oxygen-production measurements show some, on few occasions a rather high, gross-oxygen-production close to the Rocks. Maximum values ranged about 6 µMO2/l for the half day period.

- thus, the Rocks show a positive influence on phytoplankton production and concentration within the adjacent water, which forms the food source for the next members of the food web.

A more detailed description of the encountered nano-, and picophytoplankton as well as the microzooplankton communities around the Rocks can only be carried out after the detailed analyses of all samples and a profound discussion of the results.

Ichthyoplankton, Macrozoo- and Megaplankton

Ichthyoplankton, Biochemistry and Histology
B. Ueberschär (IfMK) & V. Vieira (UFRPE)

Fish larvae for nutritional condition and growth rates were collected from all the 100m BONGO-hauls. Immediately after taking the BONGO-haul, samples of both BONGO-nets (300µm and 500µm) were sorted for fish larvae. The larvae were kept on ice to prevent autolysis, transferred into Eppendorf-caps and immediately after finishing the sorting procedure the caps with the larvae were stored in a special deep-freezer (-74°C). For biochemical analysis, about 780 larvae of so far identified 30 taxa were collected on 25 of 28 stations with BONGO-hauls. One sample of flyingfish larvae for histological analyses was collected from the NEUSTON net (station 20).

The species used for biochemical analyses will be identified prior to measurements and a list about the taxa will be sent to the Brazilian coordinator, in order to complete the data on distribution and abundance of the 100m BONGO-haul.

When cephalopod larvae were detected in the samples, they were treated in the same manner as fish larvae but frozen seperately for later species analysis (Uwe Piatkowski, IfMK and Manuel Haimovici, FURG) to supplement the cephalopod larvae sorted form 50m and 150m BONGO-hauls respectively. In total, 10 cephalopod larvae from 8 stations were preserved.

Distribution and abundance of fish larvae sorted out from the 100m BONGO-haul was evaluated and are shown in Fig.3. Fish larvae were found to be most abundant close to the Rocks and in the northeast area off the Rocks. In general, abundance of fish larvae was higher in the area São Pedro/São Paulo Rocks compared to other tropical ocean areas with a uniform structure. The influence of the Rocks could produce retention areas with enhanced densities of appropriate prey organisms for fish larvae. In consequence, favourable survival conditions for fish larvae could be expected; *nutritional condition analyses of the collected larvae should give evidence about these* assumptions.

Abundance and distribution of tuna and other fish larvae
A. Röpke (NOAA), R. Lessa (UFRPE), P. Mafalda (UFRPE), C. Ebel (IfMK)

Between January 25 and February 4, 1995, 28 stations were visited around the São Pedro/São Paulo Rocks . Sampling was conducted through 150m, 100m, and 50m double oblique BONGO tows with 300µm and 500µm nets. 159 samples were taken of which 67 were already sorted aboard for tuna and other fish larvae.

The six most abundant taxa in the samples are:

Diaphus spp. (Myctophidae), Gobiidae (1 type), Vinciguerria lucetia (Photichthyidae), Lampanyctus parvicauda (Myctophidae), Bothidae (1 type), and Gonostoma spec. (Gonostomatidae).

Other groups present in the samples are:

Anguilliformes (several types of Leptocephali)
Ophidiiformes
Bramidae: *Brama sp.*
Bregmacerotidae: *Bregmaceros spp.* (*B. atlanticus*)
Carangidae
Coryphaenidae: *Coryphaena sp.*
Dactylopteridae: *Dactylopterus sp.*
Exocoetidae
Gempylidae: *Gempylus serpens, Rexea sp.*
Hemiramphidae
Labridae
Molidae: *Mola mola*
Myctophidae: *Hygophum spp., Lampanyctus spp., Myctophum spp., Symbolophorus spp.*
Paralepidae: *Lestidiops sp.*
Scombridae: *Katsuwonus pelamis, Thunnus atlanticus, T. obesus*
Serranidae
Trichiuridae

Generally, the ichthyoplankton consisted of oceanic taxa mainly, indicating the prevailing influence of the South Equatorial Current. However, surprisingly high numbers of gobiid and bothid larvae were found in offshore waters, even far away from the Rocks. This finding relates to the assumption that the Rocks have a significant influence on plankton and fish production at a subregional scale. Our preliminary data do not show a consistent horizontal gradient in ichthyoplankton occurence around the Rocks. At the vertical scale, most larvae seem to prefer the depth range betwen 50-100m, where

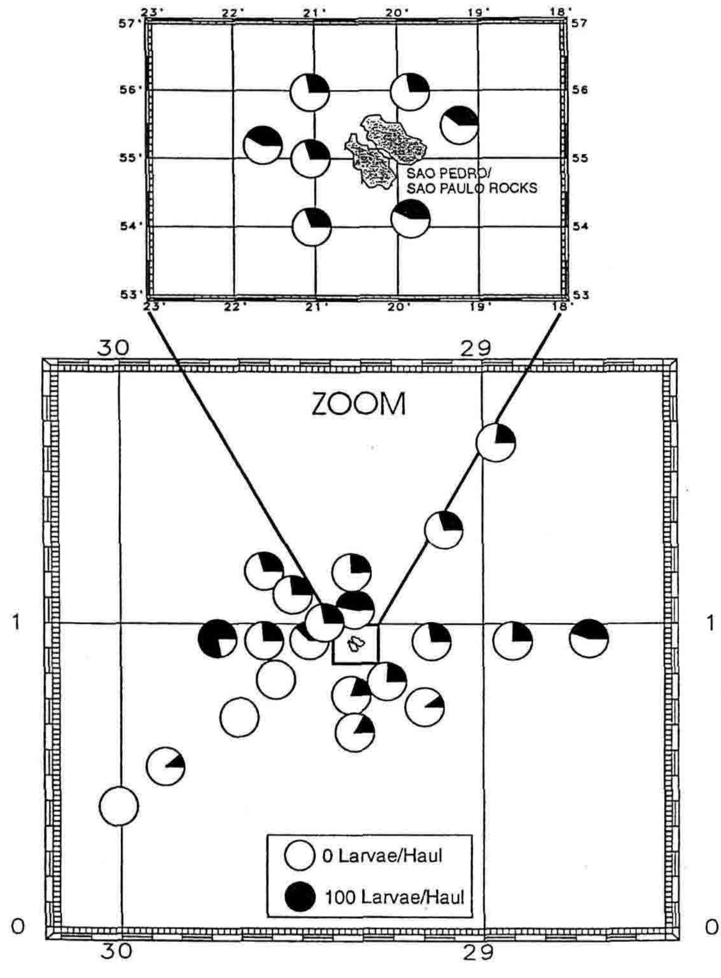

Fig.3: Abundance and density of ichthyoplankton sampled from the 100m BONGO-haul (both nets) for biochemical analyses and histology (larval performance) related to the stations visited on leg 4a is shown. A black circle indicates 100 fish larvae/haul, hollow circles indicate zero larvae/haul

the pycnocline was detected. This behaviour is typical for mesopelagic fish species.

A total of 12 valuable tuna larvae were found on five stations and identified. They were stored in 95% ETOH for further analysis.

Stat. 5, 300µm:	1 *Katsuwonus pelamis* (Skipjack tuna)
Stat. 6, 300µm:	1 *Katsuwonus pelamis*
Stat. 7, 300µm:	1 *Katsuwonus pelamis*
	1 *Thunnus atlanticus* (Blackfin tuna)
	or *Thunnus obesus* (Bigeye tuna)
Stat.17, 300µm:	1 *T. atlanticus/obesus*
Stat. 9, 300µm:	4 *T. atlanticus/obesus*
Stat. 9, 500µm:	3 *T. atlanticus/obesus*

More tuna larvae are expected in the samples which have not been sorted yet. After sorting of those samples will be finished in the laboratory in Brazil, tunas will be shiped to Miami for final evaluation (A. Röpke, RSMAS).
Larvae of flyingfish (cypselurus cf. cianopterus) were collected mainly in NEUSTON hauls. These larvae were preserved in 10% formalin for distribution and abundance studies. Seven samples were taken from the NEUSTON net and preserved in alcohol aiming to otholith studies (daily growth rates). These studies will be carried out at UFRPE (R. Lessa).

Macrozoo- and Megaplankton
K. Valenca Correia (UFPE) & J. Lins de Oliveira (UFRN)

Macrozoo- and Megaplankton, obtained using NEUSTON net in all stations and from BONGO-hauls at 150m, 100m and 50m will be analysed by K.Valenca Correia at Depto. de Zoologia, UFPE. It was agreed, that all fish larvae and cephalopod larvae will be seperated from these samples for further analyses. Lobster larvae collected by BONGO-net will be analysed by J. Lins de Oliveira, Depto. Oceanografia, UFRN, Natal.

B. Leg 4b, Cadeia Fernando De Noronha (08.02.95 - 14.02.95)

R.V "Victor Hensen" left Natal harbour in the morning (9:00) of the 8th of February towards Fernando de Noronha. In the morning of the 9th of February, "Victor Hensen" arrived in the operation area close to Fernando de Noronha and regular station work was started at 06:00 am.

Following the cruise plan, 29 stations (including 7 stations with CTD-profiles only, ref. to attached list of stations STAT02 and Fig.4) were visited around the seamounts and banks in the area of Fernando de Noronha. "Victor Hensen" left this operation area at noon of the 14th of February for Natal and arrived in the morning of the 15th of February.

In Situ measurements and sampling procedures were executed in accordance to those described for leg 4a.

Physical Oceanography
P. Travassos (UFRPE) & T.Vaske (UFRPE)

Temperature, salinity and oxygen profiles were obtained in parallel with water samples at each station using a CTD aiming to detect the hydrological structure around the oceanic islands and over seamounts, maximum launching depth was 400m.

Primary Production, Pico,- Nano- and Microplankton
T. Rodrigues Jr. (UFRPE) & G. Melo (UFPB)

The water samples for primary productivity, chlorophyll, nutrients, dissolved oxygen and fractionated plankton (pico, nano and microplankton) were taken in approriate depth ranges indicated by "Secchi-depth" and fluorescence measurements.

Simulated in situ experiments measuring gross-oxygen-production were performed on each first station of the day (S-001, S-019, S-035, S-045, S-052 and S-057) and the incubation period of the

Tab.2: List of stations, Fernando de Noronha leg 4b 08.02.-14.02.95

Stat.No. Logbook	Stat.No. JOPS II	date	time	position S	position W	depth (m)	wind (bft)	equipment lauched
70	1	9.2.	06:23	03°02,0	032°18,0	1850	N 3	SD,CTD,FL,AN,BO,NN
71	2		10:45	04°03,0	032°32,0	>3000	E2	SD,CTD,FL,AN,BO,NN
72	3		14:55	03°42,0	032°37,69	52	SE 1/2	SD,CTD,FL,AN,BO,NN,VV
73	4		18:48	03°45,0	032°33,3	>3400	E 2/3	CTD,FL,AN,BO,NN
74	5		20:58	03°53,0	032°43,0	3800	E 2/3	CTD
75	7		22:48	03°51,0	032°46,0	3700	E 2/3	CTD
76	19	10.2.	06:00	04°00,0	033°35,0	2500	SE 3	CTD,FL,AN,BO,NN
77	20		10:15	03°53,0	033°46,0	2000	SE 3	SD,CTD,FL,AN,BO,NN
78	21		17:57	03°51,0	033°54,0	>1000	SE 4	CTD,FL,AN,BO,NN
79	23		19:51	03°49,0	034°02,0	>1000		CTD
80	24		22:03	03°17,0	034°19,0	>1000		CTD
81	35	11.2.	06:00	03°25,3	035°09,0	>2000	E 4	SD,CTD,FL,AN,BO,NN
82	36		10:09	03°27,0	035°03,1	54	NE 2/3	SD,CTD,FL,AN,BO,NN,VV
83	37		12:45	03°26,8	035°11,0	>3000	NE 3	SD,CTD,FL,AN,BO,NN
84	38		18:21	03°35,0	035°01,0	50-80	NE 21	SD,CTD,FL,AN,BO,NN,VV
85	39		19:21	03°45,0	034°57,0	3100	ESE 2	CTD
86	40		20:59	04°07,0	035°00,0	3460		CTD
87	45	12.2.	06:00	04°01,5	035°41,0	2000	ENE 2/3	SD,CTD,FL,AN,BO,NN
88	46		10:00	04°09,0	035°41,1	75		CTD,FL,AN,BO,NN,VV
89	47		12:23		035°55,0	312	NE 1	SD,CTD,FL,AN,BO,NN
90	48		15:01	04°00,0	035°55,0	65		SD,CTD,FL,AN,BO,NN,VV
91	49		17:03	03°52,0	035°55,0	1900		CTD
92	52	13.2.	06:00	03°45,0	036°08,0	3000	NE 2	SD,CTD,FL,AN,BO,NN
93	53		09:21	03°54,0	036°04,0	2500	NE 2	SD,CTD,FL,AN,BO,NN
94	54		12:15	04°00,0	036°10,0	1700	NE 1	SD,CTD,FL,AN,BO,NN
95	55		15:12	04°03,0	036°16,0	>2000	NE 1	SD,CTD,FL,AN,BO,NN
96	56		20:02	03°58,0	036°16,0	>2000	NE 3	CTD,FL,AN,BO,NN,VV
97	57	14.2.	06:00	03°51,0	036°16,0	2500	NNE2/3	SD,CTD,FL,AN,BO,NN
98	58		09:41	03°51,0	036°26,0	2800	NNE 2	SD,CTD,FL,AN,BO,NN

SD:	Secchi-disk	BO:	Bongo-net
CTD:	Hydrography and Niskin bottles	NN:	Neuston-net
FL:	Fluorescence probe	CM:	Current meter
AN:	Apstein-net	VV:	Van-Veen sampler

samples was 6 hours. Samples for chlorophyll analyses were taken for all stations with CTD-coupled casts. Pico-, nano-, and microplankton were collected at 2 stations every day. Samples for nutrients were obtained for all stations with CTD casts and frozen for future analyses.

VAN-VEEN-Sampler
A. C. Beltrao (UFPE)

Whenever the station depth over seamounts was appropriate (<250m, S-003/55m, S-036/55m, S-038/80m, E-046/70m and S-048/63m), two benthos and sediment samples were collected by using a VAN-VEEN type sampler. At station S-056/237m sampling failed. Benthos were treated by passsing the samples through 250µm and 500µm sieves. Finally, the material was fixed in 10% formalin. The collected sediment was stored in plastic bags for further analyses.

Ichthyoplankton, Macrozoo- and Megaplankton

Ichthyoplankton, Biochemistry and Histology
B. Ueberschär (IfMK) & V. Vieira (IFRPE)

Fish larvae for nutritional condition (by means of enzyme analysis and histology) and growth rates were selected from all 100m BONGO-hauls. Immediately after taking the BONGO-haul, samples of both nets (300µm and 500µm) were sorted for fish larvae. The larvae were kept on ice to prevent

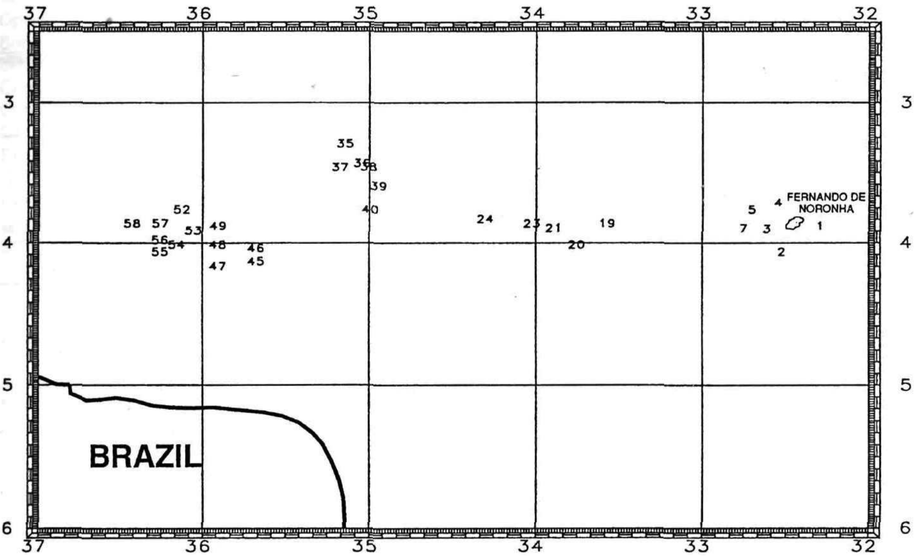

Fig. 4: The stations visited, their numbers and their locations for leg 4b is given.

autolysis, transferred into Eppendorf-caps (biochemistry) or glass vials (histology) and immediately after finishing the sorting procedure samples were stored in a special deep-freezer (-74°C). For biochemical analysis, about 680 larvae of about 30 taxa were collected on 22 stations. For histological analysis about 520 larvae were preserved in phosphate-buffered formalin or in Glutardialdehyd.

Fig.5 shows abundance and distribution for fish larvae sorted from the 100m BONGO-haul for biochemistry and histology. Highest larval abundance was located to the western most part of the grid. This will be related to condition analyses and to supplementing data (e.g. hydrography, primary production, mikrozooplankton). A high number of eel-like larvae (Leptocephalus larvae) were found at some stations compared to the usual very low densities of eel-like larvae in oceanic samples. This could indicate favourable nutritional conditions for this type of larvae which are supposed to be able to assimilate dissolved organic matter (DOM, free amino acids).

When cephalopod larvae were detected in the samples, they were treated in the same manner as fish larvae but frozen seperately for later identification and condition analysis (U.Piatkowski, IfMK and M. Haimovici, FURG). In total, 27 cephalopod larvae from 12 stations stations were preserved.

Abundance and distribution of tuna and other fish larvae
A. Röpke (NOAA), R.Lessa (UFRPE), P.Mafalda (UFRPE), C.Ebel (IfMK)

Between the 9th and the 14th of February 1995, 22 stations were sampled around the Island of Fernando de Noronha, Atol das Rocas and the adjacent seamounts and on the Sirius and the Guara Bank.

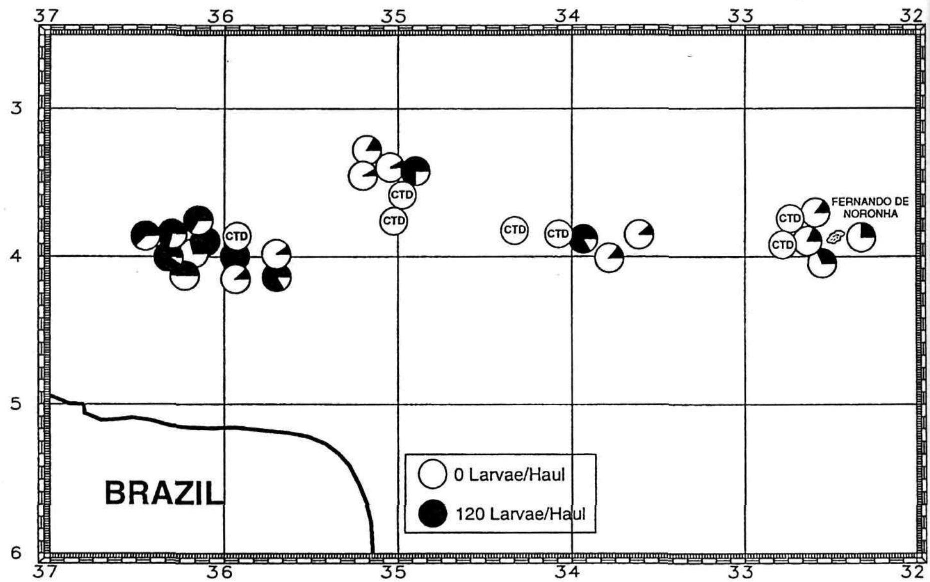

Fig. 5: Abundance and density of ichthyoplankton sampled from the 100m BONGO-haul (both nets) for biochemical analyses and histology (larval performance) related to the stations visited on leg 4b is shown. A black circle indicates 120 fish larvae/haul, hollow circles indicate zero larvae/haul. Stations with CTD casts only are noted

These areas are important fishing grounds for the tuna fishery of North-eastern Brazil. On the Sirius and Guara Bank intensive fishing activities of longliners could be observed during stationwork.

Sampling was done using a BONGO-net equiped with 300µm and 500µm nets. On every station, double oblique hauls were made down to a depth of 150 m, 100 m and 50m respectively. On this leg a total of 124 plankton samples were obtained.

59 samples have been sorted for Scombrid i.e tuna larvae yielding 9 identified tuna larvae and 6 larvae which showed meristic caracteristics of tuna larvae. These larvae will need further verification and identification in detail in the laboratory in Miami (A. Röpke, RSMAS).

Differences of the total number of caught larvae could be observed between samples taken at full daylight and samples taken during dusk and in the evening. It must be considered that the given sampling design (i.e. sampling during daylight) could underestimate the "real" abundance of fish-larvae significantly.

The ichthyoplankton community of the sampled areas revealed typical oceanic characteristics with dominating taxa of Myctophidae, Photichthyidae and Gonostomatidae.

Other groups present in the samples were:

Anguilliformes (several types of Leptocephali)
Ophidiiformes
Bothidae
Bregmacerotidae: *Bregmaceros spp.* (*B. atlanticus*)
Carangidae
Coryphaenidae
Dactylopteridae
Exocoetidae
Gobiidae
Hemiramphidae
Labridae
Serranidae
Trichiuridae

The 9 identified tuna larvae and the 6 questionable larvae were stored in 95% ETOH for further analysis.

Macrozoo- and Megaplankton
K.Valenca Correia (UFPE) & J.Lins de Oliveira (UFRN)

Macrozoo- and Megaplankton obtained using NEUSTON net at all stations and from BONGO-hauls from 150m, 100m and 50m will be analysed by Kenia Valenca Correia, Depto. Zoologia, UFPE, as described in the first section of this report (2.3.3.3). Lobster larvae collected by BONGO-net will be analysed by Jorge Lins de Oliveira, Depto. Oceanografia, UFRN.

C. Leg 4c, Cadeia Norte Brasileira (16.02.95 - 22.02.95)

RV "Victor Hensen" left the port of Natal on 16th February, 1995 and arrived in the study area on 17th February. Between the parallels 1°20' and 3°40'S and meridians 37° and 39°W routine work was performed on 17 stations (+ 3 stations with CTD casts only, ref. to list of stations STAT03 and Fig. 6) using the equipment and sampling procedures as described in the first section of the report.

Physical Oceanography
P. Travassos (UFRPE) & T.Vaske (USP)

Temperature, salinity and oxygen profiles were obtained in parallel with water samples at each station using a CTD aiming to detect the hydrological structure around and over seamounts, maximum launching depth was 400m.

Primary Production, Pico,- Nano,- and Microplankton
N. Lins Da Silva (UFPE) & G. Melo (UFPE)

The water samples for primary productivity, chlorophyll, nutrients, dissolved oxygen and fractionated plankton (pico, nano and microplankton) were taken in approriate depths indicated by "Secchi-depth" and fluorescence measurements.

Simulated in situ experiments measuring gross-oxygen-production were performed on each first station of the day (S-004, S-005, S-019 and S-039) due to the long incubation period of samples (6 hours). Samples for chlorophyll analyses were taken for all stations with CTD casts.

Samples for pico, nano and microplankton analyses were collected at two stations each day. Samples for nutrient analyses were obtained for all stations with CTD casts and frozen for future analyses.

Tab.3: List of stations, Cadeia del Norte leg 4c 16.02.-22.02.95

Stat.No. Logbook	Stat.No. JOPS II	date	time	position S	position W	depth (m)	wind (bft)	equipment launched
99	5	17.2.	06:32	03°13,0	037°39,0	600	E 2	SD, CTD, FL, AN, BO, NN
100	6		10:15	03°14,0	037°51,0	2200	E 1/2	SD, CTD, FL, AN, BO, NN
101	7		13:24	03°05,0	037°47,0	2000	E 1	SD, CTD, FL, AN, BO, NN
102	8		17:45	03°02,0	037°35,0	>1000	CALM	CTD, FL, AN, BO, NN
103	19	18.2.	06:00	02°06,0	037°45,0	2500	NE 2/RAIN	SD, CTD, FL, AN, BO, NN
104	18		09:15	01°59,0	037°54,0	2000	NE 3	SD, CTD, FL, AN, BO, NN
105	17		12:00	01°57,0	037°49,0	50	NE 3	SD, CTD, FL, AN, BO, NN, VV
106	15		14:06	01°51,0	037°52,0	1300	NE 3	SD, CTD, FL, AN, BO, NN
107	27		16:55	01°57,0	037°58,0	3000		CTD
108	28		18:19	01°51,0	038°07,0	3000		CTD
109	30		19:55	01°45,0	038°17,0	2500	E 3/RAIN	CTD
110	39	19.2.	06:00	01°26,0	038°53,0	3000	NNE 3	SD, CTD, FL, AN, BO, NN
111	37		09:49	01°27,0	038°41,9	54	NNW 2/3	SD, CTD, FL, AN, BO, NN, VV
112	36		11:48	01°32,0	038°43,0	46	NNW 2/3	SD, CTD, FL, AN, BO, NN, VV
113	35		14:10	01°40,0	038°45,0	2000	ROTATING 1	SD, CTD, FL, AN, BO, NN
114	34		19:13	01°40,0	038°31,5	2500	ROT 1/RAIN	CTD, FL, AN, BO, NN
115	4	20.2.	07:08	03°19,0	037°32,0	283	E 3	SD, CTD, FL, AN, BO, NN
116	3		10:41	03°27,0	037°24,0	251	E 3	SD, CTD, FL, AN, BO, NN, VV
117	2		14:25	03°34,0	037°16,0	>2000	ESE 3	SD, CTD, FL, AN, BO, NN
118	1		19:00	03°39,0	037°10,0	2500	ESE 3	SD, CTD, FL, AN, BO, NN

SD:	Secchi-disk	BO:	Bongo-net
CTD:	Hydrography and Niskin bottles	NN:	Neuston-net
FL:	Fluorescence probe	CM:	Current meter
AN:	Apstein-net	VV:	Van-Veen sampler

VAN-VEEN-Sampler
A.C. Beltrao (UFPE)

On selected stations with shallow water (<250m, S-017/45m, S-036/42m and S-037/55m, two casts at each station) benthos and sediment samples were collected by using a VAN-VEEN type sampler. Sampling on station S-03/250m failed. Benthos were treated by passing through 250µ and 500µm sieves. All the material was fixed in 10% formalin, the sediment was stored in plastic bags for further analyses .

Ichthyoplankton, Macrozoo- and Megaplankton

Ichthyoplankton, Biochemistry and Histology
B. Ueberschär (IfMK) & V. Vieira (IFRPE)

For all stations on leg 4c (with exceptiôn of shallow stations <150m), 3 double oblique BONGO-hauls were conducted: 150m, 100m and 50m. Fish larvae for nutritional condition and growth rates were selected from all 100m BONGO-hauls and sorted as described in the corresponding sections above. On 17 stations, about 335 larvae for biochemical measurements and about 300 larvae for histological techniques were sampled. These larvae were immediately frozen or preserved in buffered formalin aiming on studies of nutritional condition using biochemical (enzymes studies) and histological techniques. Fig.7 shows abundance and distribution for fish larvae sorted from the 100m BONGO-haul for biochmistry and histology. Highest larval abundance was located to the southern most part of the grid.

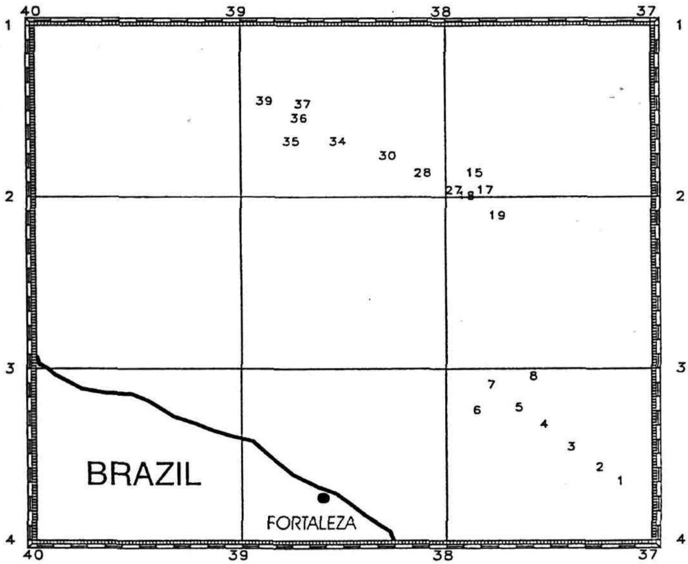

Fig. 6: The stations visited, their numbers and their locations for leg 4c .

When cephalopod larvae were detected in the samples, they were treated in the same manner as fish larvae but frozen seperately for later identification and condition analysis (U.Piatkowski, IfMK and M. Haimovici, FURG). In total, 16 cephalopod larvae from 7 stations were sorted from the 100m BONGO-hauls and preserved.

Abundance and distribution of tuna and other fish larvae
A. Röpke (NOAA), R.Lessa (UFRPE), P.Mafalda (UFRPE), C.Ebel (IfMK)

The 50m and 150m samples were sorted out semiquantitatively aboard prior to preservation and identified to the lowest possible taxon in order to obtain additional larvae from all fish species for histological analyses (ref. to 2.5.4.1.). Remaining samples were preserved in formaldehyde (4%) for complete analysis.

The so far identified taxa are:

Anguilliformes
Ophidiidae
Mictophidae
Syngnathidae
Dactylopteridae

Exocetidae
Hemiramphidae
Scorpenidae
Photichthydae
Ceratoidei
Carangidae
Serranidae
Paralepidae
Gobiidae
Balistidae
Diodontidae
Tetradontidae
Bothidae

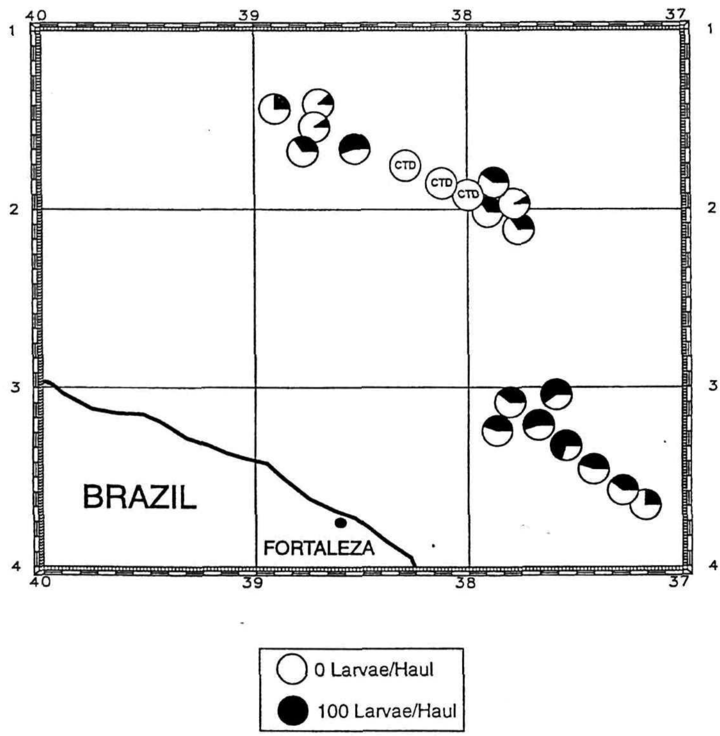

Fig. 7: Abundance and density of ichthyoplankton sampled from the 100m BONGO-haul (both nets) for biochemical analyses and histology (larval performance) related to the stations visited on leg 4c. A black circle indicates 100 fish larvae/haul, hollow circles indicate zero larvae/haul. Stations with CTD casts only are noted.

Just a few specimens of each identified taxa were present in the samples. This will probabily make it difficult to analyse the nutritional condition of fish larvae by using histological techniques.
All tuna larvae present in the 100m samples were kept separetely for further confirmation of species by A. Röpke, RSMAS, after which they will be sent back to the Brazilian coordinator.
NEUSTON net hauls were conducted at every station with BONGO-hauls, these samples were completely fixed in formaldehyde (10%).

Macrozoo- and Megaplankton
K.Valenca Correia (UFPE) & J.Lins de Oliveira (UFRN)

Macrozooplankton, obtained using NEUSTON hauls and BONGO samples at 150m, 100m and 50 m will be analysed by K. Valenca Correia at Depto. de Zoologia, UFPE as mentioned in the first section of this report (2.3.3.3). Lobster larvae- collected by BONGO-net will be analysed by J. Lins de Oliveira, Depto. Oceanografia, UFRN.

Data Bank

The following section is a comprehensive list of responsibilities for the samples collected during JOPSII, leg 4, and should serve as a reference board for all participants of leg 4 in order to locate any sample and place of processing when corresponding informations are needed.
CTD - Temperature, salinity, dissolved oxygen, pH and density profiles are going to be analysed by ***Fabio Hazin*** and ***Paulo Travassos*** from Departamento de Pesca-UFRPE.
Fluorescence - profiles of relative chlorophyll concentration will be analysed by ***Michael Meyerhöfer*** and ***Klaus von Bröckel*** from IfMK, ***Roberto Sassi, Gilson Melo*** and ***Gilson F. de Moura*** from Nepremar-UFPB and ***Paulo Travassos*** from Departamento de Pesca-UFRPE.
Primary Production - data will be processed and analysed by ***Roberto Sassi, Gilson Melo*** and ***Gilson Moura*** from Nepremar-UFPB, ***Paulo Travassos*** from Departamento de Pesca-UFRPE and ***Klaus von Bröckel,*** IfMK. **POC, PON, fractionated Chlorophyll a, C/N ratio** and **pigments (carotinoide, HPLC)** will be measured by ***Michael Meyerhöfer***, IfMK.
Pico and Nanoplankton - will be analysed by ***Nadja Lins da Silva*** from Departamento de Zoologia-UFPE and ***Klaus von Bröckel,*** IfMK.
Microplankton - was sampled using NISKIN-Bottles and will be processed by ***Nadja Lins da Silva*** from Departamento de Zoologia-UFPE, ***Roberto Sassi, Gilson Melo*** and ***Gilson Moura*** from Nepremar-UFPB and ***Klaus von Bröckel,*** IfMK.
Microzooplankton - sampled with a plankton net (100µm and 20µm mesh size) will be analysed by ***Roberto Sassi, Gilson Melo and Gilson Moura*** from Nepremar-UFPB.
Nutrients - will be analysed by ***Nilton de Oliveira*** and ***Paulo Travassos*** from Departamento de Pesca-UFRPE.
Macro and Megaplankton - sampled by BONGO-net and NEUSTON net is going to be analysed by ***Kenia Valenca Correia*** from Departamento de Zoologia-UFPE. It was agreed, that all fish larvae and cephalopod larvae will be seperated from these samples and will be passed to the responsible parties for further analyses.
Lobster larvae - collected by BONGO-net will be studied by ***Jorge Lins de Oliveira*** from Departamento of Oceanography and Limnology-UFRN, Natal.
Fish larvae - from BONGO-net (100m depth only) will be studied under aspects of **nutritional condition** and **growth rates** by using biochemical techniques by ***Bernd Ueberschär*** from IfMK. A list of the species collected for biochemical analyses will be sent to the brazilian coordinator after finishing biochemical measurements in order to complement data in relation to the studies of distribution and abundance. Studies on **nutrional condition** of larvae using **histological techniques** will be carried out by ***Vera Vieira*** from Departamento de Pesca- UFRPE, larvae used for this evaluation will be identified by the scientist doing histology.
Tuna larvae from BONGO-net hauls will be identified by ***Andreas Röpke*** and ***William Richards,*** RSMAS and will be sent back to Brazil for **otholith studies** (daily rings) carried out by ***Rosangela Lessa*** and ***Teodoro Vaske Jr.*** Departamento de Pesca - UFRPE.

Taxonomy of other fish larvae from BONGO-net (50 and 150m) and neuston hauls will be done by ***Paulo Mafalda Junior***, from Departamento de Zoologia II - UFBA supported by ***Andreas Röpke***, RSMAS and ***Vera Vieira,*** Departamento de Pesca-UFRPE. The **remaining components** of these samples will be analysed by ***Rosangela Lessa*** and ***Teodoro Vaske Junior*** from Departamento de Pesca - UFRPE.

II. Distribution and condition of selected *meroplankton* (*fish- and cephalopod larvae*) in relation to oceanographic and ecological conditions

Methodical approach

Individual determination of the nutritional condition of fish- and cephalopod larvae by means of biochemical methods (proteolytic enzyme activity, additionally RNA/DNA analysis with cephalopod larvae).

Sampling

During the period of 28.01.95 - 04.02.95, samples were taken on a grid around the Sao Pedro/Sao Paulo rocks. The detailed sampling schedule and the number of larvae sampled for these investigations is described in the cruise report of leg 4.

Tab.1: Synoptic summary of data about the larvae investigated for the nutritional condition from leg 4a for each species: Total number of larvae individually analysed, their mean length, their mean enzyme activity and the number of stations where the respective larval type was found in the samples.

PART A	JOPSII - LEG 4a						
SPECIES, TYPE	A	B	C	D	E	F	G
NUMBER OF LARVAE	43	10	78	42	118	15	84
STANDARD LENGTH MEAN (mm) ±STDEV. MAX. SL (mm) MIN. SL (mm)	8.7 0.8 11.0 7.0	8.9 1.5 11.0 7.5	5.4 0.8 8.0 4.0	5.2 0.9 8.0 4.0	4.6 0.9 8.0 3.0	6.8 1.3 8.5 5.0	5.0 0.8 9.0 3.5
MEAN TRYPTYC ENZYME ACTIVITY nMOL/LARVA/min. ±STDEV. MAX. (nMOL) MIN. (nMOL)	0.49 0.55 2.98 0.037	0.30 0.19 0.73 0.128	0.84 0.93 7.10 0.091	0.679 1.156 7.14 0.008	0.98 2.07 19.14 0.01	5.87 6.13 20.07 0.691	2.94 6.77 42.03 0.090
LOCATED AT n-STATIONS FROM A TOTAL OF 29	3	3	10	7	13	4	4
PART B							
SPECIES, TYPE	H	I	J	K	L	M	O
NUMBER OF LARVAE	20	19	30	37	2	6	5
STANDARD LENGTH MEAN (mm) ±STDEV. MAX. SL (mm) MIN. SL (mm)	7.7 3.8 23.0 5.5	4.4 0.9 7.0 3.5	10.7 3.1 18.0 7.0	7.8 1.3 12.0 6.0	5.8 1.8 7.0 4.5	13.7 5.0 23.0 8.0	7.2 1.3 8.0 5.0
MEAN TRYPTYC ENZYME ACTIVITY nMOL/LARVA/min. ±STDEV. MAX. (nMOL) MIN. (nMOL)	2.45 4.46 13.98 0.164	2.854 4.12 12.85 0.273	1.65 1.50 5.98 0.091	0.30 0.89 5.52 0.001	3.83 1.02 4.54 3.110	3.39 6.45 16.55 0.380	6.11 2.33 9.63 4.00
LOCATED AT n-STATIONS FROM A TOTAL OF 29	6	2	13	4	2	5	4

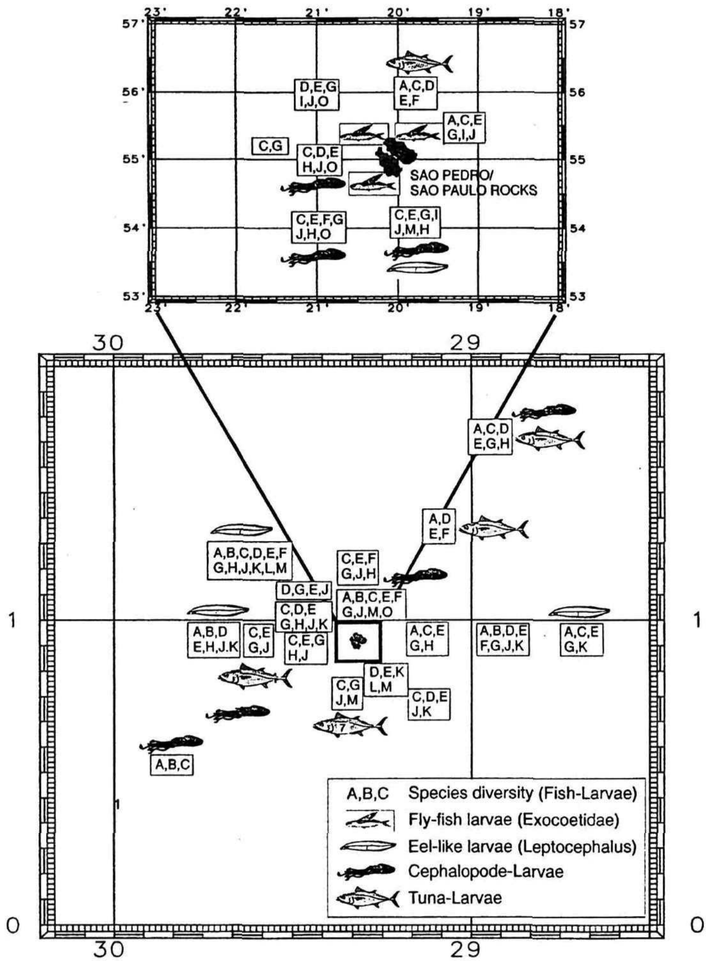

Fig. 1: Distribution of fish larvae investigated for the nutritional condition from leg 4a. The different species are indicated by letters. Symbols are indicating stations, where other types of larvae were found in the samples but not analysed: Leptocephali-like larvae, flying fish larvae (Exocoetidae) and cephalopod larvae.

The sorted fish larvae were kept frozen in a deep freezer aboard (-74°C). In the laboratory, prior to analysis, larvae were thawed and examined by using a binocular. Damaged larvae were discarded, other larvae identified as a certain type (named with a letter), specific features noted (e.g. gut content) and finally homogenized (the procedure to determine individual proteolytic enzyme activity is described in detail in UEBERSCHÄR 1988).

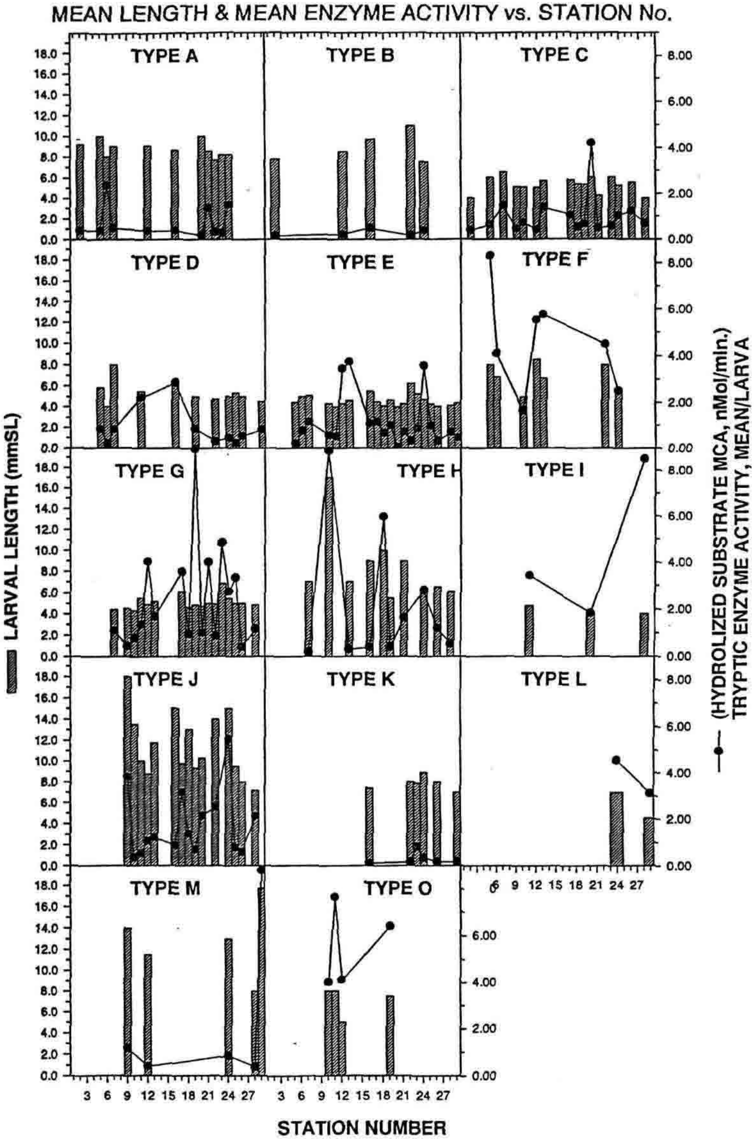

Fig. 2: Mean larval length and mean enzyme activity per station for each analysed larval type. Values are means of 2-21 individuals/station. Exocoetidae) as well as the stations where cephalopod larvae were found in the samples

To avoid any autolysis, this procedure has to belimited to a very short time and does not allow the final identification of the species. For this purpose, larvae from each type investigated were preserved in buffered formalin for later identification with support of an expert for tropical ichthyoplankton.

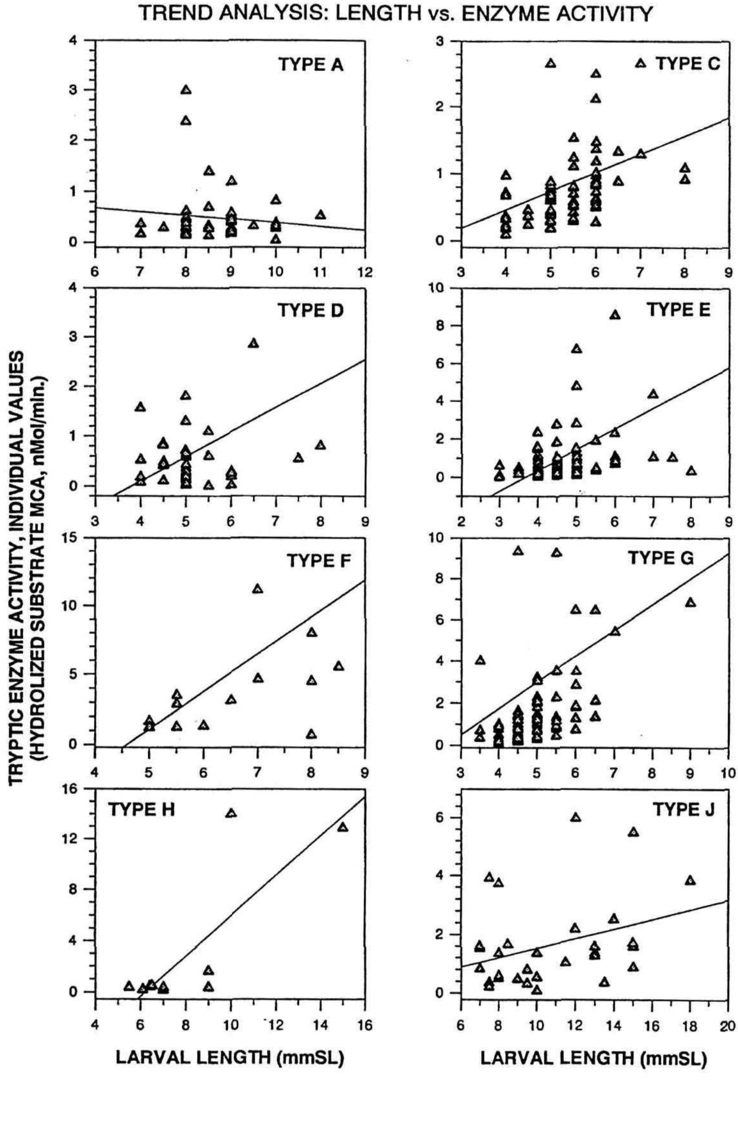

Fig. 3: Correlation of larval length and tryptic enzyme activity for some selected species. Each value represents an individual measured larvae.an isolated stock of this species is established in the area of the rocks.

Results

For this working report, only results from leg 4a are available, the preliminary results are presented in the following section.

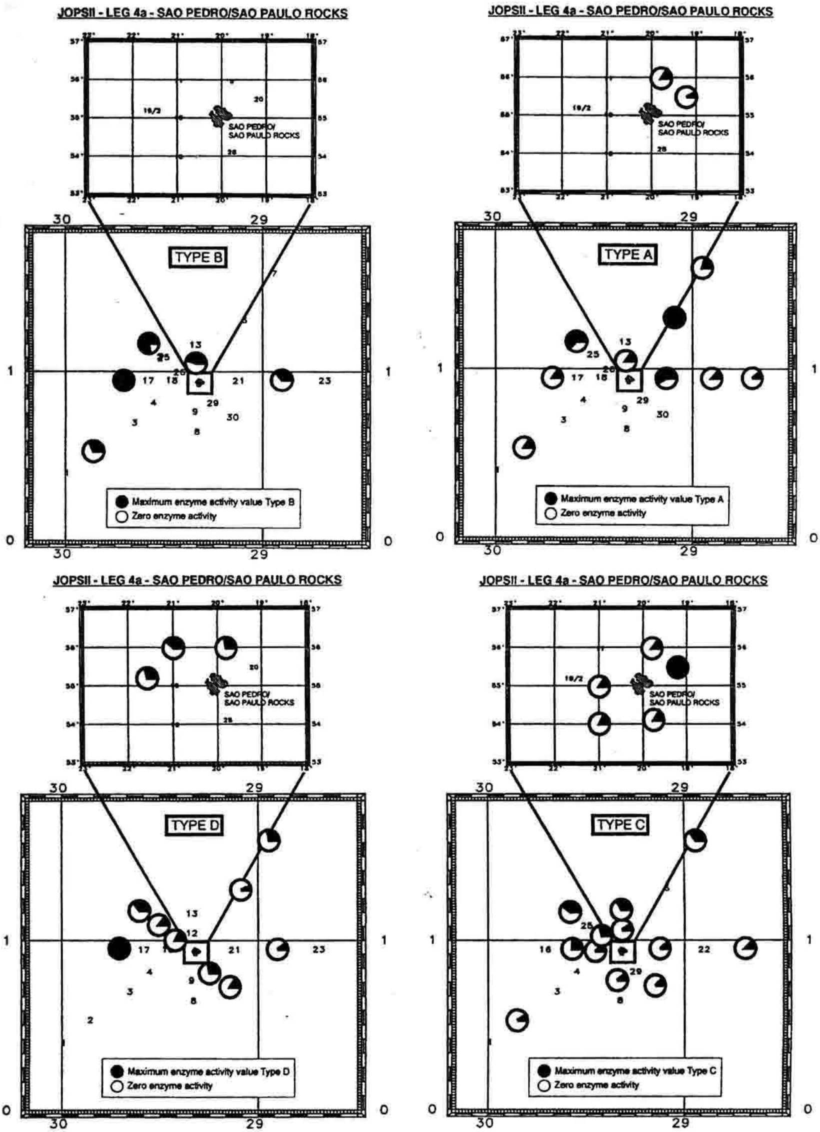

Fig. 4a-d: Relative enzyme activity/station as a percentage of the highest mean value measured per larval type per station. The black circle indicates the highest activity value found (=100%), hollow circles indicate 0% of the highest activity. Presentation for all types of larvae which were found on several stations in a comparable number.

Larval distribution

The distribution of the different types of fish larvae individually analysed for nutritional condition is given in Fig. 1 for each station at the grid around the rocks (as letters). The symbols are indicating

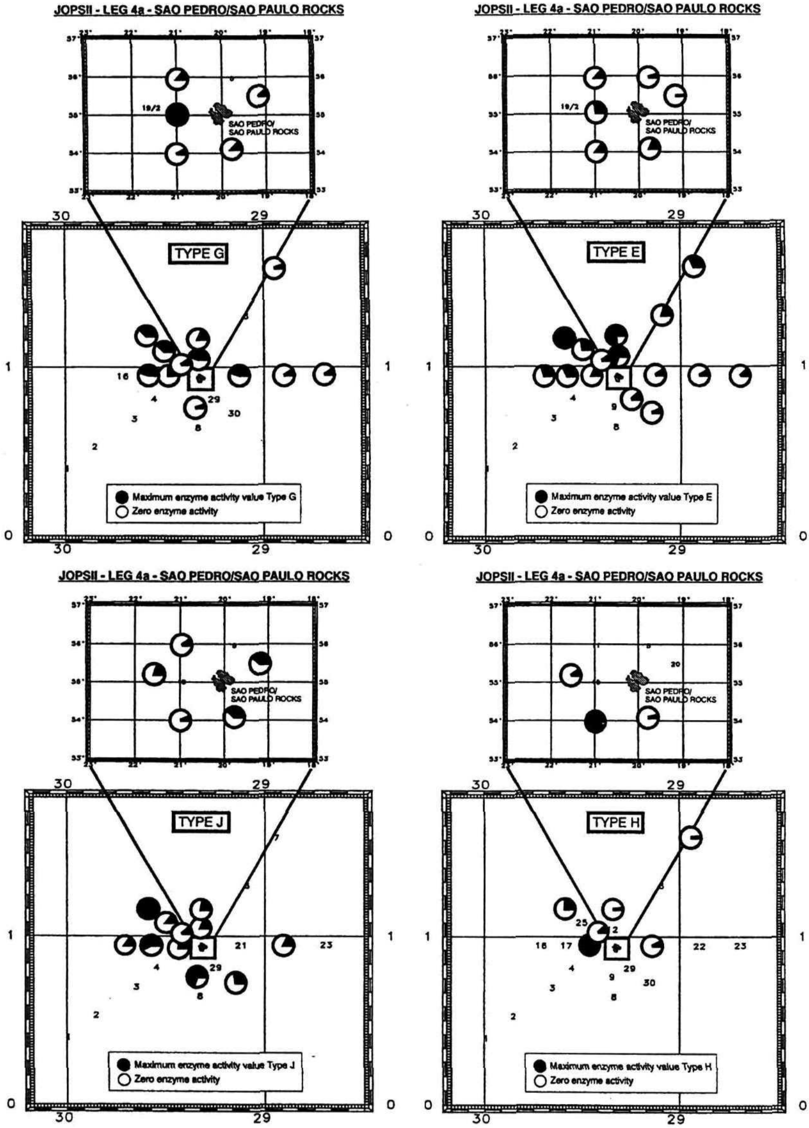

Fig. 4e-h: Relative enzyme activity/station as a percentage of the highest mean value measured per larval type per station. The black circle indicate the highest activity value found (=100%), hollow circles indicate 0% of the highest activity. Presentation for all types of larvae which were found on several stations in a comparable number

other types of larvae which were not included into the condition analyses (Leptocephali, Scombridae, Exocoetidae) as well as the stations where cephalopod larvae were found in the samples. In the north-east area off the rocks, the highest abundance and species diversity was found. The larval type E and J were the most abundant type of larvae in the samples, type E and G were the species with the highest numbers. Larval type I was only found in samples at stations close to the rocks.

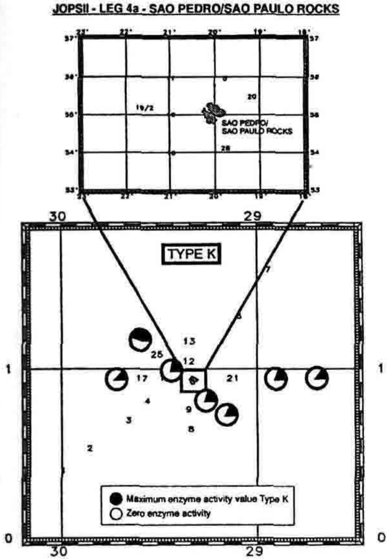

Fig. 4i: Relative enzyme activity/station as a percentage of the highest mean value measured per larval type per station. The black circle indicates the highest activity value found (=100%), hollow circles indicate 0% of the highest activity. Presentation for all types of larvae which were found on several stations in a comparable number

Unexpected high numbers of larvae from flatfish (Bothidae) were found in the samples around the rocks. This kind of fish is typical for the littoral but not in high oceanic areas. The final larval distribution will be available when all Bongo hauls were sorted and can differ from the presentation in this report, but the tendency is supposed to be very similar.

The relatively high abundance of Leptocephalus-like larvae in this area compared to other oceanic areas indicates a favourable nutritional situation for this type of larvae which is supposed to be able to assimilate DOM (dissolved organic matter). Higher DOM values as the mean values for open sea conditions would indicate nutrient enriched water masses which would support the hypothesis of the "island mass effect" in the area of the rocks.

Analysis of enzyme activity

Due to length-dependency of proteolytic enzyme activity in fish larvae, the estimation of the nutritional condition by analysis of individual proteolytic enzyme activity requires fish larvae in a similar length range within the same species. Fig.1 demonstrates the relationship between mean larval length/station and enzyme activity. With the most of the investigated species, the mean length values are very similar, more pronounced differences were found for type H and J. Therefore, differences in the mean enzyme activity values of different groups of larvae with a similar length can be attributed to the nutritional condition.

The positive correlation between enzyme activity and larval length is demonstrated in Fig. 3 for all investigated species. It is shown, that an increase in larval length is correlated with an increase in enzyme activity, but the differences in length have to be considerable to have an effect on the enzyme activity. High differences in enzyme activity within groups of larvae with comparable length (small differences) are caused most probably by differences in the nutritional condition (as proved in numerous laboratory experiments with larvae from different species).

The mean values of enzyme activity for the larval types A,B,C;D,E,G,H,J and K are shown for each station (Fig. 4 a-i) where these larvae were found in a reasonable amount (some values with larger than the double standard deviation were not regarded for the calculation of the mean values). North-east of the rocks, a tendency towards higher enzyme activities can be observed, especially at station 24, where the highest number of larvae and the highest diversity was found (ref. Fig.1). For further interpretation, the data about the abundance of potential food (mikrozooplankton) are needed.

With Table 1, a synoptic view about the available data in relation to enzyme activity analyses are given for each type of larva. Number of larvae individually measured, their mean length, mean tryptic enzyme activity and their abundance is noted.

From laboratory experiments it is known, that the mean digestive enzyme capacity is species specific. Therefore, the differences in the mean values of enzyme activity for the different investigated species are mainly specific for each type and not due to differences in length or condition.

The estimation of larvae in a bad condition is based on laboratory calibration experiments with four different species (herring, turbot, cod and sea bass larvae). These results were used to calculate a

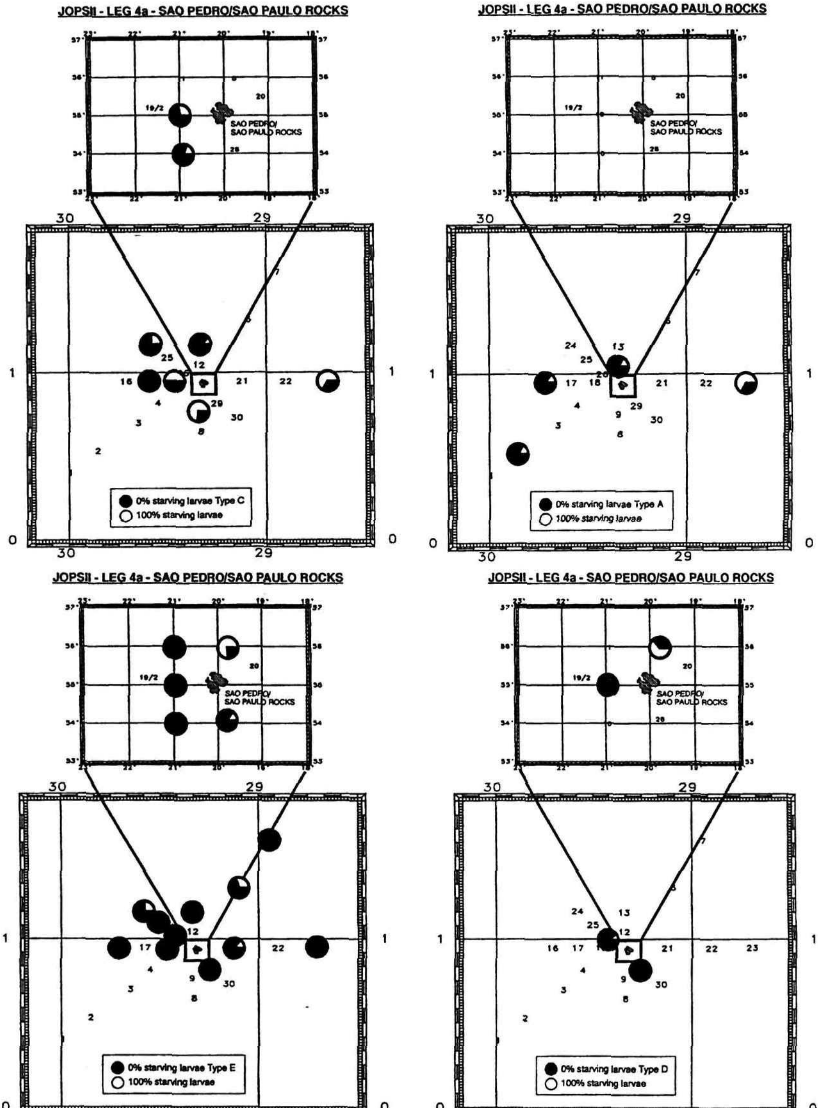

Fig. 5a-d: Estimation of the nutritional condition of some selected species (larval types with more than 5 individuals analysed) based on laboratory calibration data. Filled circles indicate 0% of larvae in a bad condition, hollow circles indicate 100% of larvae in a bad condition

factor, the evaluation of the number of larvae/station in a bad condition is based on this factor. The relative amount of larvae in a bad condition is given in Fig. 5a-f for some selected species. On the basis of this evaluation it can be concluded that most of the larvae were found to be in a good condition.

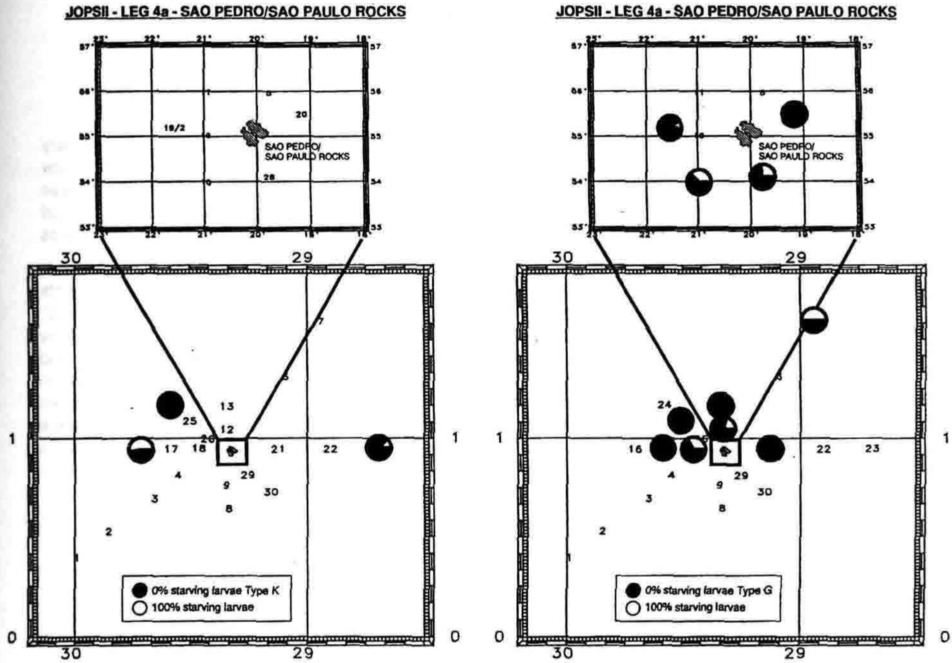

Fig. 5e-f: Estimation of the nutritional condition of some selected species (larval types with more than 5 individuals analysed) based on laboratory calibration data. Filled circles indicate 0% of larvae in a bad condition, hollow circles indicate 100% of larvae in a bad condition.

In general, estimation of starving larvae in field samples based on calibration experiments with species, different from the field larvae, includes uncertainties about the exact amount of starving larvae, but no substantial difference in the relation between the stations is expected.

Summary

Fish larvae sampled on leg 4a in order to investigate their nutritional condition in relation to hydrographic and biotic environment were completely analysed, the preliminary results are described in this working report. In the north-east area of the investigated grid, the highest abundance and diversity with fish larvae was found. Larvae from this area showed the highest enzyme activities, indicating an excellent condition. The reason for this finding is not yet clear, because the biotic background (primary production, microzooplankton) for leg 4a is not yet completely available. Based on these first results, starvation is supposed not to be of high significance for the larvae investigated.

III. Physical and biological features close to the Rocks of São Pedro and São Paulo - preliminary results -

K. von Bröckel (IfMK) & M. Meyerhöfer (IfMK)

Objectives

In general, tropical oceanic regions far away from any continental coast show a low primary productivity. This is due to a rather stable mixed layer reaching below the euphotic zone with low nutrient concentrations. Seamounts which reach into the mixed layer as well as islands within these oceanic regions are on the other hand surrounded by a surprisingly rich sealife. Especially local fisheries take advantage of this phenomenon. So, traditional local fisheries on tunas and other fishes exist in the vicinity of the Rocks of São Pedro and São Paulo.

The maintenance of high standing stocks of pelagic organisms near islands and seamounts suggests that these areas are locations for high rates of energy transfer (Boehlert & Genin 1987; Rogers 1994). The energy which drives the enhanced biological productivity may either be generated from local small-scale hydrographic processes or be advected from elsewhere and concentrated at the islands and seamounts (Boehlert & Genin 1987). It has been suggested that in oligotrophic waters the uplifting of isotherms into the euphotic zone induced by seamount structures results in the formation of Taylor columns (Boehlert & Mundy 1993). This phenomenon can increase local nutrient concentration and thus enhance primary production (Genin & Boehlert 1985). Evidence for increased primary production leading to aggregations of zooplankton and nekton at seamounts is yet not well documented.

One of the objectives during the leg JOOPS II/4 a was the description of the hydrographical situation around the Rocks of Sao Pedro and Sao Paulo and the study of their influence on distribution of nutrients as well as composition and production of the phytoplankton community (see also the report of B. Ueberschär).

Material and Methods

Sampling

On the leg JOPS II/4 a, between January 28. and February 4. 1995, 27 stations were sampled on eight transects approaching the Rocks. Distances between stations and Rocks ranged from about 55 nautical miles to about half a nautical mile. Water samples were taken at each station from five light depths (100 %, 30 %, 10 %, 1 % and 0,1 %) calculated from Secchi disc readings with water bottles (each 10 l) attached to the ctd-probe. From 27 stations sampled, on 8 'early morning' stations oxygen uptake was measured (Fig. 1).

The exact locations of stations sampled, as well as the sampling procedure are given in detail within the cruise-report of B. Ueberschär.

Nutrients

Samples for nutrients (nitrate, nitrite, phosphate and silicate) were taken from the light depths, immediately deep frozen and are to be analysed in Brazil. The data for the characterization of the 'island-mass effect' are not yet available.

Biological parameter

Samples for phytoplankton pigments (HPLC), chlorophyll, particulate organic carbon (POC), particulate organic nitrogen (PON), micro-pytoplankton composition and nanoplankton composition were taken at all stations from the light depths mentioned.

On the 'early morning' stations dissolved oxygen was determined in water samples from light depths on five stations close to the Rocks and from three stations relatively far away, to detect possible influences of the Rocks. From the same depths water was incubated (simulated in situ) for oxygen production. For each depth 2 light and 1 black bottle (250 ml, PE) were incubated on deck from about sunrise to noon. Oxygen concentrations were measured with an automatic oxygen stand (SIS). Oxygen production was determined as the difference between the oxygen concentration of the

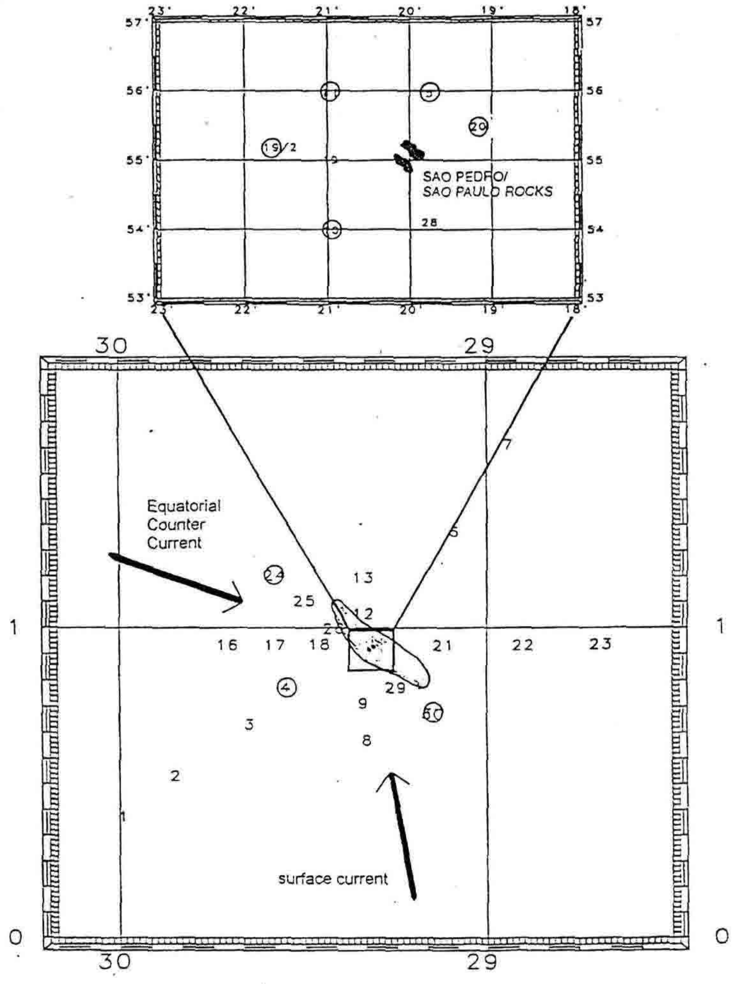

Fig. 1: Rocks of Sao Pedro and Sao Paulo with the underwater plateau, stations sampled, "early morning" stations (encircled) and direction of surface and subsurface currents (North Equatorial Counter Current)

dark and the light bottles at the end of the incubation period and calculated as oxygen production in µM/day.

The method of oxygen uptake for productivity determinations instead of the 14C-method had to be chosen out of technical reasons. No handling of radioactive material was allowed on board RV "Victor Hensen". Because the oxygen-method is not that sensitive, results obtained have to be regarded cautiously, especially within this oligotrophic region where the uppermost water layers are normally oxygen-saturated (about 100 %) or even oversaturated (>100 %).

Results

General surroundings

The Rocks of São Pedro and São Paulo are situated at about 55° N and 29° 19' W. The rocks themselves rise only about 15 m above sea surface. The plateau, they are situated on, rises sharply from several thousand meters (between 2000 and 4000 m) to less than 200 m water depth. The several rocks cover an area of about 150 m x 30-40 m. The underwater plateau stretches from southeast to northwest with an extension of about 5 x 30 nautical miles (Fig. 1).

The Rocks are situated within the North Equatorial Counter Current with an easterly direction and rather high current speeds of up to 100 cm/sec within its core in about 80 m depth. Own current measurements were taken on February 3. on four stations (stat. 10, 11, 19, 20) around the Rocks with a current meter attached to the hydrographical wire in six depths (5, 20, 40, 60, 80 and 100 m). They showed a northern surface current (towards 350° with a speed of 25 cm/sec), most probably induced by the prevailing easterly winds. Below the surface current the North Equatorial Counter Current was found extending from 20 to 100 m depth. Its direction was about 105° (between 90 and 130°) with an average speed of 27 cm/sec (with a maximum of 38 cm/sec in 100 m).

Water column (Temperature, salinity and Secchi disc)

So far, only raw and uncalibrated data from the CTD are available. It is assumed that they give the general picture, although absolute values might be different.

Average sea surface temperatures and salinities with values of 27.5°C (min. 26.7 and max. 28.1°C) and 35.6 ppt (min. 35.4 and max. 35.8 ppt) respectively were rather uniform on all stations sampled. That is, no upwelling features could be observed in the sea surface around and further away from the Rocks.

Temperature and salinity profiles down to 150 m for the eight 'early morning' stations are presented in Fig. 2. These profiles are a typical selection from all stations. They show a very uniform salinity

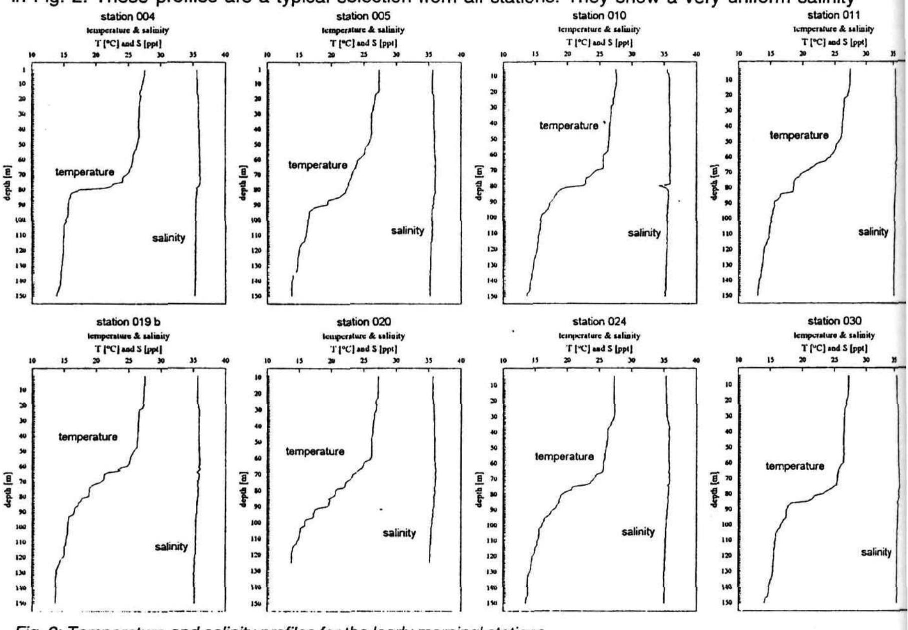

Fig. 2: Temperature and salinity profiles for the 'early morning' stations

throughout the water column with a very slight increase with depth. Temperature profiles show the mixed layer reaching down to between 60 and 90 m. The thermocline was either very pronounciated with a high gradient (stat. 04, 10 and 30) or stretched over a greater width with a small gradient (stat. 05, 11, 19b, 20 and 24). Close to the Rocks all stations had a thermocline with a small gradient stretching over about 40 to 60 m, whereas further away from the Rocks all types of temperature profiles could be observed. Unfortunately nutrient values are not yet available. They are needed to see whether these different thermoclines are connected with a recent mixing of water due to currents influenced by the topography around the Rocks and the underwater plateau. During such processes nutrients could be brought into the lower part of the euphotic zone and thus enhance primary production. On the other hand, these observed differences between the thermoclines could be due to different current systems encountered. As such they could be older features, showing no recent mixing.

Secchi disc readings, ranging from 21 to 32 m, were typical for oligotrophic oceans. No differences could be observed close to the Rocks compared to further away, or between luffside and leeside of the Rocks in regard to the current system.

Biological Parameter (POC, PON, Chl a and Pigments)

The distribution of particulate organic carbon (POC), particulate organic nitrogen (PON) and clorophyll a is presented in Fig. 3 for the eight ^early morning^ stations. They are typical examples for all stations visited. In general POC and PON values are somewhat higher in surface and subsurface waters. Here too, no relation could be found between distance of station from the Rocks and distribution as well as total values of POC and PON. That is, no indication for an influence of the Rocks on the amount and distribution of the particulate organic material suspended in the water could be found.

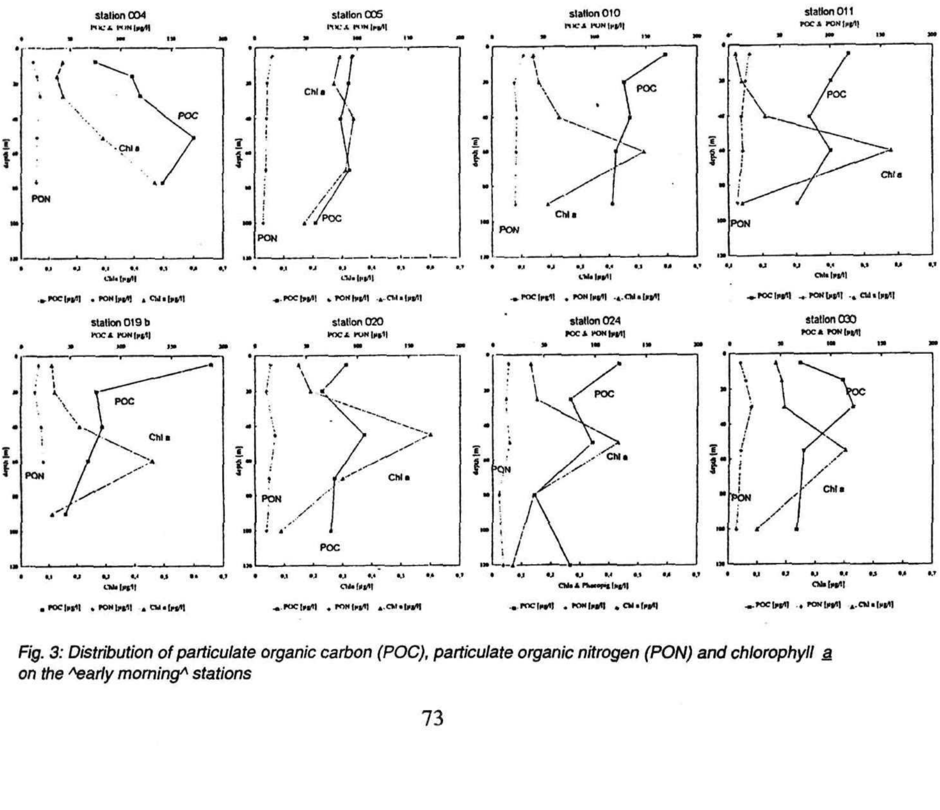

Fig. 3: Distribution of particulate organic carbon (POC), particulate organic nitrogen (PON) and chlorophyll a on the ^early morning^ stations

Concentrations of chlorophyll a normally increased rapidly with depth, showing a very pronounciated chlorophyll maximum at the end of the euphotic zone (in about 10 % light depth). Low surface values and maxi-mal values were around 0.15 and 0.6 g µg Chla /l. But there are also stations with a deeper chlorophyll maximum (in about 0.1 % light depth) or with a rather uniform distribution of chlorophyll a within the water column. No relation could be found between distance of station from the Rocks and distribution or concentrations of chlorophyll a. That is, no indication for an influence of the Rocks on amount and distribution of chlorophyll a could be found.

Determination of chlorophyll a concentrations within different size fractions (>20 µm, 20-2 µm, 2-0.8 µm and <0.8 µm) for one station close to the Rocks (stat 11) and one station about 30 nautical miles on the luffside of the Rocks (stat 30) revealed some differences (Fig. 4).

On both stations chlorophyll a concentrations are mainly due to phytoplankton in the size class smaller than 2 µm. Far away from the Rocks this fraction represents more than 90 % of the chlorophyll a in both depths. Whereas close to the Rocks the importance of the size fraction between 20 and 2 fm is remarkable with about 27 % and 18 % in 5 and 60 m depth respectively. This difference can also be observed in the relationship of different phytoplankton pigments to chlorophyll a (Fig. 5).

The markerpigments **zeax**anthin and **chl**orophyll **b** indicate the presence of cyanobacteria (Synechococcus type) and prochlorophytes, both typical for oligotrophic regions with regenerated production. These two pigments are dominant at both stations and in all depths. On the other hand **peri**dinin, 19-**but**anoyl-oxy-fucoxanthin and 19-**hex**anoyl-oxy-fucoxanthin gain importance at the station near the rocks. These pigments demonstrate a higher contribution of dinoflagellates, chrysophytes and prymnesiophytes, indicating a greater availability of new nutrients. This corroborates the results of the size fractionation, showing a higher contribution of bigger phytoplankton at the near rock station.

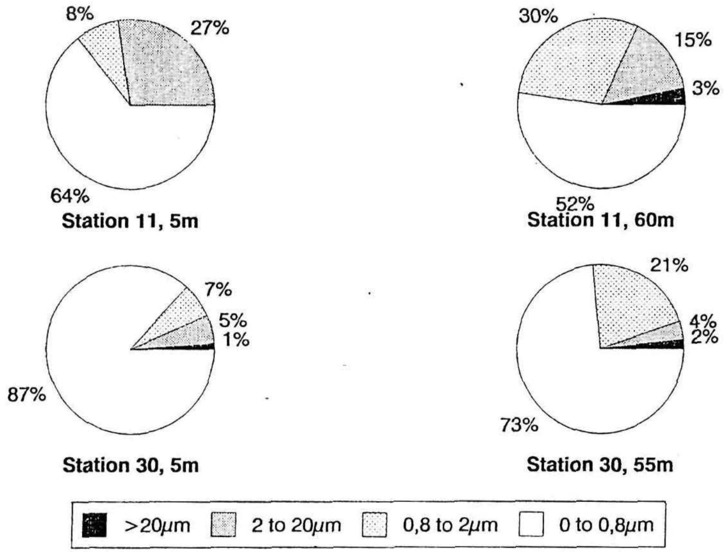

Fig. 4: Distribution of chlorophyll a in different size fractions for two depths (5 and 60 m) of station 11 (close to the Rocks) and for two depths (5 and 55 m) of station 30 (distance to the Rocks about 30 nautical miles)

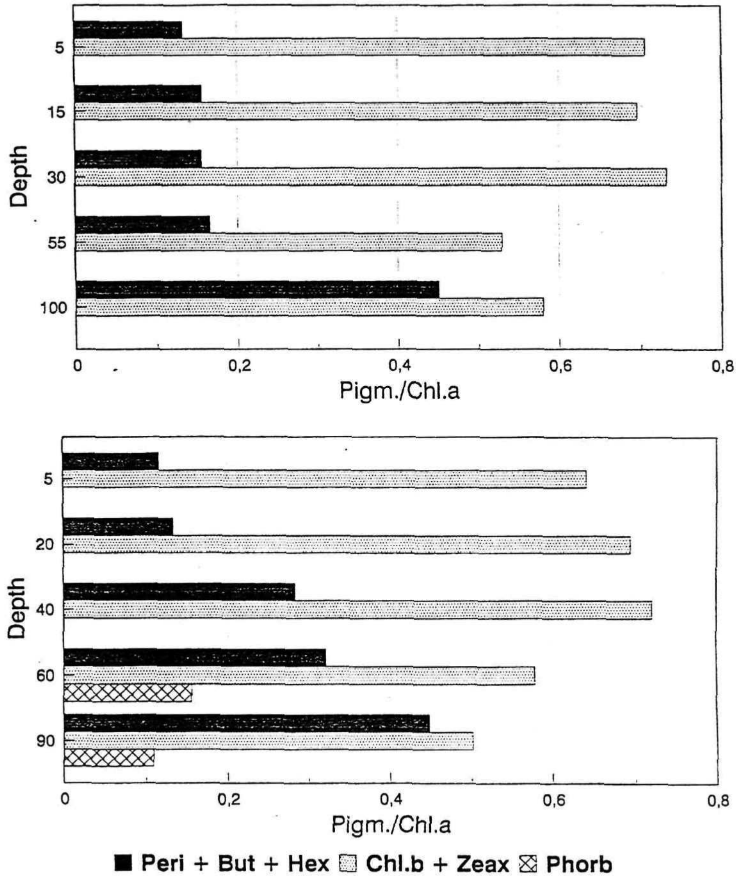

Fig. 5: Ratio of marker pigments to chlorophyll a for station 11 (close to the Rocks) and for station 30 (distance to the Rocks about 30 nautical miles)

The presence of pheophorbides indicates a higher grazing activity of mesozooplankton at this station.

But due to the statements made above, it is not clear whether these differences between station 11 and 30 really demonstrate different regimes with different phytoplankton populations due to effects induced by the Rocks. This can only be determined after further HPLC-analyses of samples from the other stations.

Oxyggen production

Oxygen production measured on the 'early morning' stations ranged from detection limits up to nearly 20 µM/d. Higher values were always found within the 10 % light depth. No differences between stations close to the Rocks and stations in a greater distance from the Rocks could be found. This might be partly due to the problems with this method mentioned above.

General conclusions

At the present stage, where many important data are yet not calibrated and/or available for a comprehensive interpretation, only a limited description of the situation around the Rocks of São Pedro and São Paulo is possible:

- From all the data presented above no clear evidence arises for an influence of the Rocks on the physical and biological environment around them, specially not for an enhanced primary production within the water column and/or an increase in particulate organic material available (seston). The somewhat 'normal' differences within an oligotrophic ocean might enclose the situations around the Rocks. Or the 'island mass effect' looked for, covers such a huge area that our sampling strategy did not grasp it.

- Visual observation during the cruise showed a clear aggregation of fishes, specially rather big flying fishes, around and close to the Rocks. Local fisheries around the Rocks on tunas indicated a high production. It is speculated, that the rather high Equatorial Counter Current provides the phytobenthic community of the Rocks and the plateau with a steady flow of water with nutrients although in low concentrations. Thus increasing benthic primary production which furtheron supports a rather rich ecosystem.

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Leg 5: Influence of mangroves on diversity and productivity of the coastal waters off Northeast Brazil

Chief scientists: Dr. W. Ekau (ZMT), Dr. C. Medeiros (UFPE)

Cruise report

Objectives

The main goal of this work is to evaluate the contribution of mangrove systems to the productivity and diversity of coastal waters along the Brazilian Continental Shelf between LAT. 3° and 9° S.

The aims are (1) to quantify the amount of organic matter and nutrient exportation originated at major rivers along the NE-Brazilian coast within this region; (2) to obtain a small scale description of the horizontal and vertical distribution and abundance of phyto, zoo and ichthyoplankton along NE-brazilian shelf waters; (3) to estimate the primarily productivity of these waters; (4) to map and quantify resurgence areas; and (5) to characterize the abiotical coastal environment from its hydrographical and hydrodynamical point of view.

Related works and justification

Mangrove forests form highly complex ecosystems in the transition zone from fresh to saltwater. They cover about 70% of the area in tropical estuaries and are frequented by a diverse variety of animal taxa for their maturation. Larval and juvenile fishes and prawns encounter a rich diet on the roots and in the sediments. Many fish species from shelf seas use mangrove forests as nurseries where they spend at least their juvenile stages. This type of tropical forests is believed to highly contribute to coastal waters productivity, through the export of organic matter and nutrients. The extension and form of this contribution as well as the processes involved are however still not well known.

The major aim of this work was to evaluate the importance of this type of system to the productivity and diversity of coastal waters. The project is related to other studies completed or being developed within mangrove systems as Itamaracá, PE (DO UFPE/ZMT), Suape Complex, PE (DO UFPE), Mundaú/Manguaba Complex, AL (PORTOBRÁS/UFAL), Maxaranguape and Potengi, RN (UFRN), among others.

The work was jointly developed by researchers from the Departamento de Oceanografia da Universidade Federal de Pernambuco and from the Zentrum für Marine Tropenökologie at Bremen. Researchers from the Universidade Federal da Paraíba also joint the project for specific tasks. The area of investigation was of special interest for both parts of the cooperation, the Brazilian and the German scientists.

Work at sea

<u>Itinerary</u>

The ship left the port of Recife on February 24, 1995. A first station was sampled in the afternoon to test the instruments. Regular station work began on February 25, in the morning with a transect off the Rio Formoso estuary. From that time on, one transect perpendicular to the coast was worked up every day, starting at the station nearest to the coast at low tide. This scheme was followed until entering the port of Natal, on March 5. Two additional stations were done in front of the mouths of the Itamaracá estuary on March 4 during night to get some comparative samples at varying daytime.

The ship left Natal on March 6 and started routine work again on March 7 with a transect off Natal. One transect off the northeast cape of Brazil and three off Ceará were carried out during the next days, starting at the oceanic stations of the transect, and to reach the coastal stations at low tide again.

The ship finished its station work on March 11, at 19.00 hours and headed towards the port of Fortaleza, where the cruise leg JOPS-II-5 ended in the morning of March 12, 1995.

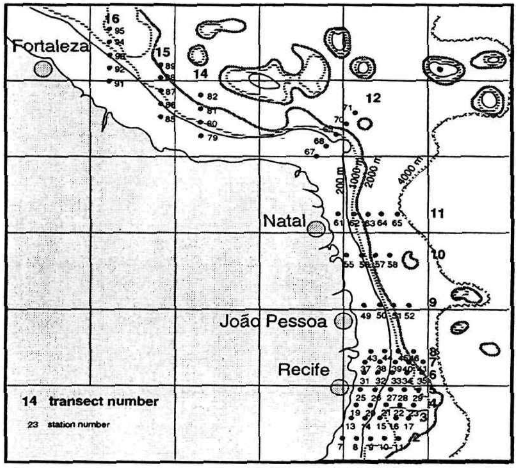

Fig. 1: Station plan of the JOPS-II-5 cruise leg

Physical oceanography
C. Medeiros (UFPE)

To describe the hydrographical situation in the investigation area, at all stations CTD profiles were obtained using a ME-CTD probe with a pH sensor. They were realized from surface to near bottom or for the top 400 m layer (limit of cable length). Data will be used to infer the distribution of various waters masses, to compute the geostrophic circulation and delimit the area of influence of coastal waters.

Current speed and direction measurements were taken with a SENSORDATA SD6000 mini current meter.Measurements were done at the top 15 to 30 m layer of the 2 most coastal stations of each profile (total of 28), but 2 data files were lost due to misfunctioning of the instrument. Data will be used to aid in infering local circulation and will have to be digitized manually. The work should be accomplished by June 1996.

Marine chemistry
S. Macedo (UFPE), C. Medeiros (UFPE), I. Freitas (UFPE)

Water samples were collected by means of VanDorn bottles in 66 stations, distributed in 14 profiles perpendicular to the coast. In the continental shelf the samples were taken at three depths (according to the topography) and in the oceanic region at five depths (0, 50, 100, 150 and 200 meters). Aboard 198 samples could be processed for oxygen and 254 samples were frozen for posterior analysis of Nitrit, Nitrat, Phospate and Silicone at the Chemistry division of the Depart. of Oceanography in Recife.

The dissolved oxygen was determined after the methodology reported by Strickland and Parsons (1972) based on the Winkler method. The nutrient salts will be determined according to the methodology reported by Grasshoff (1972).

Water samples were taken at the 3 most coastal stations of each profiles with a total of 42 stations covered. Samples werd filtered and frozen for later determination of TSJ and particulate carbon, at the lab of Physical Oceanography at UFPE. The work will be accomplished by June 1996.

Phytoplankton
A. Stuhr (IfMK), F. Feitosa (UFPE), F. Carvalho (UFPB)

Primary production measurements using the oxygen production method have been done on at least one, sometimes two stations a day. Water samples were obtained at one to five depths.

The samples have been incubated on board at different light intensities (100, 50, 30, 10, 1 and 0.1% light depth). To get an impression of the occurring "oxygen-producers" we took additional netcatches for microscoping on board. To characterize the light conditions in the water the Secchi-disk was deployed at each station. Further fluorescence profiles were derived at every station by a sensor measuring chlorophyll a fluorescence. These profiles indicate phytoplankton abundance in the watercolumn.

It will take about one year until the data that have been recieved on this cruise have been worked out. There will be a close cooperation with Prof. Fernado Feitosa from the Universidade Federal de Pernambuco in Recife.

Zooplankton

Nanoplankton
S. Neumann (UFPE)

In each station a nanoplankton sample (was collected with a Dorn bottle from the surface, totalizing 69 samples. All samples have been conserved in Lugol solution.

The samples will be analysed in the Phytoplankton section of the Dep. de Oceanografia of the Federal University of Pernambuco in Recife by using an inversed microscope. Results are expected to be ready until June 1996.

Microzooplankton
S. Neumann (UFPE)

Microzooplankton was collected with nets of 64 and 120 µm mesh size, mounted on a Bongo frame of 20 cm of diameter. A total number of 70 (64µm) and 69 (120µm) samples was collected. The 120µm sample from station 13 was lost. At station 56 both size fractions were lost.

The samples were conserved in 4% formaldehyd solution. They will be analysed in the Zooplankton laboratory at the Department of Oceanography at the UFPE, Recife. A compound microscope (64µm fraction) and a binocular microscope (120µm) will be used for this work. Results are expected to be presented until June 1996.

Crustacean plankton
R. Schwamborn (ZMT)

A total of 71 samples were collected for the analysis of decapod larvae distribution. Mesh used was 300 µm. The nets were mounted in a Bongo frame. The samples were conserved immediately after the catch in 4% formalin and will be analysed for species composition and abundance in the laboratory in Recife. First rough results are expected to get until June 1996. Final results will be presented on a bilateral workshop on the results of JOPS-II in 1996 or 1997.

A number of 26 non-quantitative samples were collected to measure the carbon-isotope content in order to distinguish the source of alimentation of the decapod larvae. The samples were concentrated and deep frozen immediately after the catch. The samples will be prepared in the Dep. of Oceanography in Recife, the measurement of carbon-isotopes will be carried out in Germany. Results are expected to be available also until June 1996.

Fish larvae
W. Ekau (ZMT)

A total of 115 samples were collected for the analysis of fish larvae distribution. Mesh used was 500 µm. The nets were mounted in a Bongo frame (71 hauls) and to catch the fish larvae at the surface, in a Neuston-sledge frame (44 hauls).

The samples were conserved immediately after the catch in 4% formalin and will be analysed for species composition and abundance in the laboratory in the Center for Tropical Marine Ecology in Bremen. First rough results are expected to get until June 1996. Final results will be presented on a bilateral workshop on the results of JOPS-II in 1997.

Tab. 1: Station list JOPS-II-5

Transect nr.	Stat. nr.	Latitude		Longitude		Date	Time	Gear used
	0	08 °	41,5 S	35 °	01,2 W	24.2.1995	16:40	Experimental station for CTD, MN, CM
1	1	08 °	50,0 S	34 °	54,9 W	skipped		
1	2	08 °	50,0 S	34 °	54,9 W	skipped		
1	3	08 °	50,0 S	34 °	44,9 W	skipped		
1	4	08 °	50,0 S	34 °	34,9 W	skipped		
1	5	08 °	50,0 S	34 °	24,9 W	skipped		
1	6	08 °	50,0 S	34 °	14,9 W	skipped		
2	7	08 °	41,5 S	35 °	01,2 W	25.2.1995	6:00	SD, FS, BO, NS, CTD, WS, CM
2	8	08 °	41,5 S	34 °	51,2 W	25.2.1995	9:30	SD, FS, BO, CTD, WS, CM
2	9	08 °	41,5 S	34 °	41,2 W	25.2.1995	11:37	SD, FS, CTD, WS, BO, NS
2	10	08 °	41,5 S	34 °	31,2 W	25.2.1995	14:42	FS, SD, CTD, WS, BO, NS
2	11	08 °	41,5 S	34 °	21,2 W	25.2.1995	16:44	NS, BO, CTD, WS
2	12	08 °	41,5 S	34 °	11,2 W	skipped		
3	13	08 °	24,5 S	34 °	54,4 W	26.2.1995	7:00	SD, FS, CTD, WS, CM, CTD, BO, NS MN
3	14	08 °	24,5 S	34 °	44,4 W	26.2.1995	10:09	CM, FS, SD, CTD, WS, BO
3	15	08 °	24,5 S	34 °	34,4 W	26.2.1995	12:15	CM, FS, CTD, WS, BO, NS, MN
3	16	08 °	24,5 S	34 °	24,4 W	26.2.1995	15:45	FS, SD, CTD, BO
3	17	08 °	24,5 S	34 °	14,4 W	26.2.1995	17:54	BO, NS, FS, CTD, WS
3	18	08 °	24,5 S	34 °	04,4 W	skipped		
4	19	08 °	13,8 S	34 °	52,0 W	27.2.1995	7:30	WS, CTD, SD, FS, CM, BO, BO, NS
4	20	08 °	13,8 S	34 °	42,0 W	27.2.1995	9:30	SD, FS, CM, CTD,WS, BO, BO, MN
4	21	08 °	13,8 S	34 °	32,0 W	27.2.1995	11:59	MN, NS, FS, WS, CTD, SD, BO
4	22	08 °	13,8 S	34 °	22,0 W	27.2.1995	15:20	FS. SD. CTD. BO
4	23	08 °	13,8 S	34 °	12,0 W	27.2.1995	17:33	FS, CTD, WS, BO, NS, MN
4	24	08 °	13,8 S	34 °	02,0 W	skipped		
5	25	08 °	03,0 S	34 °	48,2 W	28.2.1995	7:40	FS, CM, CTD, WS, BO, BO, NS
5	26	08 °	03,0 S	34 °	37,5 W	28.2.1995	9:57	FS, SD, CM, CTD, WS, BO, BO, MN
5	27	08 °	03,0 S	34 °	27,5 W	28.2.1995	12:27	FS, SD, CTD, WS, BO, BO, NS, MN
5	28	08 °	03,0 S	34 °	17,5 W	28.2.1995	15:48	FS, SD, CTD, WS, BO
5	29	08 °	03,0 S	34 °	07,5 W	28.2.1995	18:00	FS, CTD, WS, BO, BO, NS
5	30	08 °	03,0 S	33 °	57,5 W	skipped		
6	31	07 °	49,0 S	34 °	45,6 W	1.3.1995	8:48	FS, SD, CM, CTD, WS, BO, BO, NS
6	32	07 °	49,0 S	34 °	34,6 W	1.3.1995	11:29	CM, CTD, WS, SD, FS, BO, BO, BO, NS
6	33	07 °	49,0 S	34 °	24,6 W	1.3.1995	14:00	FS, SD, CTD, BO, BO, BO, NS, WS
6	34	07 °	49,0 S	34 °	14,6 W	1.3.1995	17:50	FS, CTD, WS, PN, WS, BO
6	35	07 °	49,0 S	34 °	04,6 W	1.3.1995	20:32	BO, NS, CTD, WS
6	36	07 °	49,0 S	33 °	54,6 W	skipped		
7	37	07 °	41,5 S	34 °	44,3 W	2.3.1995	9:27	CM, FS, SD, CTD, WS, PN, BO, BO, NS
7	38	07 °	41,5 S	34 °	33,3 W	2.3.1995	12:12	CM, FS, CTD, PN, BO, BO, NS, WS
7	39	07 °	41,5 S	34 °	23,3 W	2.3.1995	15:05	WS. FS, CTD, WS, BO, BO, BO, NS
7	40	07 °	41,5 S	34 °	13,3 W	2.3.1995	18:40	FS, BO, CTD, WS
7	41	07 °	41,5 S	34 °	03,3 W	2.3.1995	20:54	BO, NS, FS, WS, CTD
7	42	07 °	41,5 S	33 °	53,3 W	skipped		
8	43	07 °	33,0 S	34 °	40,5 W	3.3.1995	9:45	FS, SD, WS, CTD, CM, BO, BO, NS
8	44	07 °	33,0 S	34 °	30,5 W	3.3.1995	12:40	CM, PN, CTD, BO, BO, NS, SD, WS
8	45	07 °	33,0 S	34 °	20,5 W	3.3.1995	15:30	FS, SD, CTD, WS, BO, BO, BO, NS
8	46	07 °	33,0 S	34 °	10,5 W	3.3.1995	19:23	FS, PN, CTD, BO, WS
8	47	07 °	33,0 S	34 °	00,5 W	skipped		
8	48	07 °	33,0 S	33 °	50,5 W	skipped		

BO=Bongo net, CM=current meter, CTD=Temperature/salinity sonde, FS=Fluorescence sonde, NS=Neuston net, MN=Multi net, SD=Secchi Disc, WS=Water sample

Tab. 1: Station list JOPS-II-5 cont.

Trans-ect nr.	Station nr.	Latitude		Longitude		Date	Time	Gear used
	31	07 °	49,0 S	34 °	45,6 W	4.3.1995	0:40	FS, CTD, WS, BO, BO, NS
	37	07 °	41,5 S	34 °	44,3 W	4.3.1995	2:43	CTD, BO, BO, NS
9	49	06 °	56,5 S	34 °	43,9 W	4.3.1995	10:45	SD, FS, CM, PN, CTD, WS, BO, NS
9	50	06 °	56,5 S	34 °	33,9 W	4.3.1995	13:32	FS, PN, CM, CTD, BO, NS, WS
9	51	06 °	56,5 S	34 °	23,9 W	4.3.1995	17:05	FS, PN, CTD, WS, BO, NS
9	52	06 °	56,5 S	34 °	13,9 W	4.3.1995	20:04	FS, CTD, BO, NS, WS
9	53	06 °	56,5 S	34 °	03,9 W	skipped		
9	54	06 °	56,5 S	33 °	53,9 W	skipped		
10	55	06 °	18,7 S	34 °	58,3 W	5.3.1995	12:40	CM, FS, SD, PN, CTD, BO, NS, WS
10	56	06 °	18,7 S	34 °	48,3 W	5.3.1995	10:40	CM, FS, SD, PN, CTD, WS, BO
10	57	06 °	18,7 S	34 °	38,3 W	5.3.1995	8:30	FS, SD, CTD, BO, WS
10	58	06 °	18,7 S	34 °	28,3 W	5.3.1995	6:00	FS, PN, CTD, WS, BO, NS
10	59	06 °	18,7 S	34 °	18,3 W	skipped		
10	60	06 °	18,7 S	34 °	08,3 W	skipped		
11	61	05 °	45,0 S	35 °	03,2 W	7.3.1995	14:28	CM, FS, SD, PN, CTD, BO, NS, WS
11	62	05 °	45,0 S	34 °	53,2 W	7.3.1995	17:10	NS, BO, CM, FS, PN, CTD, WS
11	63	05 °	45,0 S	34 °	43,2 W	7.3.1995	10:37	FS, CM, CTD, WS, BO, NS
11	64	05 °	45,0 S	34 °	33,2 W	7.3.1995	8:17	FS, SD, PN, CTD, WS, BO, WS
11	65	05 °	45,0 S	34 °	23,2 W	7.3.1995	5:57	FS, PN, CTD, WS, BO
11	66	05 °	45,0 S	34 °	13,2 W	skipped		
12	67	04 °	58,3 S	35 °	18,7 W	8.3.1995	16:28	CM, FS, SD, PN, CTD, WS, BO, NS
12	68	04 °	50,8 S	35 °	12,0 W	8.3.1995	14:14	CM, FS, SD, PN, CTD, BO, WS
12	69	04 °	43,3 S	35 °	05,3 W	8.3.1995	11:14	FS, SD, PN, CTD, WS, BO, NS
12	70	04 °	35,8 S	34 °	58,6 W	8.3.1995	8:34	FS, SD, PN, CTD, BO, WS
12	71	04 °	28,3 S	34 °	51,9 W	8.3.1995	6:00	PN, FS, CM, CTD, WS, BO
12	72	04 °	20,8 S	34 °	45,2 W	skipped		
13	73	04 °	51,7 S	36 °	18,0 W	skipped		
13	74	04 °	41,7 S	36 °	18,0 W	skipped		
13	75	04 °	31,7 S	36 °	18,0 W	skipped		
13	76	04 °	21,7 S	36 °	18,0 W	skipped		
13	77	04 °	11,7 S	36 °	18,0 W	skipped		
13	78	04 °	01,7 S	36 °	18,0 W	skipped		
14	79	04 °	42,3 S	36 °	42,0 W	9.3.1995	17:22	CM, FS, SD, CTD, BO, BO, NS, WS
14	80	04 °	32,3 S	36 °	42,0 W	9.3.1995	13:55	CM, FS, PN, CTD, WS, SD, BO, BO, NS
14	81	04 °	22,3 S	36 °	42,0 W	9.3.1995	10:48	FS, SD, PN, CTD, BO, BO, NS, WS
14	82	04 °	12,3 S	36 °	42,0 W	9.3.1995	8:24	FS, SD, PN, CTD, WS, BO
14	83	04 °	02,3 S	36 °	42,0 W	9.3.1995	6:00	FS, PN, CTD, BO, WS
14	84	03 °	52,3 S	36 °	42,0 W	skipped		
15	85	04 °	28,4 S	37 °	10,0 W	10.3.1995	16:40	CM, FS, SD, CTD, WS, BO, BO, NS
15	86	04 °	18,4 S	37 °	10,0 W	10.3.1995	13:45	CM, FS, SD, CTD, BO, BO, NS, WS
15	87	04 °	08,4 S	37 °	10,0 W	10.3.1995	11:03	FS, SD, PN, CTD, WS, BO, BO
15	88	03 °	58,4 S	37 °	10,0 W	10.3.1995	8:38	FS, SD, PN, CTD, BO, WS
15	89	03 °	48,4 S	37 °	10,0 W	10.3.1995	6:00	FS, PN, CTD, WS, BO
15	90	03 °	38,4 S	37 °	10,0 W	skipped		
16	91	04 °	00,2 S	37 °	46,0 W	11.3.1995	17:54	BO, BO, NS, WS, CM, CTD, PN, FS
16	92	03 °	50,2 S	37 °	46,0 W	11.3.1995	15:14	CM, FS, SD, PN, CTD, WS, BO, BO, NS
16	93	03 °	40,2 S	37 °	46,0 W	11.3.1995	11:53	FS, SD, PN, CTD, BO, BO, NS, WS
16	94	03 °	30,2 S	37 °	46,0 W	11.3.1995	9:18	FS, SD, PN, CTD, WS, BO
16	95	03 °	20,2 S	37 °	46,0 W	11.3.1995	5:57	FS, SD, PN, CTD, WS, BO
16	96	03 °	10,2 S	37 °	46,0 W	skipped		
17	97	03 °	36,0 S	38 °	28,0 W	skipped		
17	98	03 °	26,0 S	38 °	28,0 W	skipped		
17	99	03 °	16,0 S	38 °	28,0 W	skipped		
17	100	03 °	06,0 S	38 °	28,0 W	skipped		
17	101	02 °	56,0 S	38 °	28,0 W	skipped		
17	102	02 °	46,0 S	38 °	28,0 W	skipped		

First results

The influence of mangrove forests on the northeastern coast of Brazil

I. Physical and chemical aspects

S. Macedo (UFPE), C. Medeiros (UFPE), I. Lins-Correia (UFPE)

Mangrove forests have a worldwide influence on the cycling of estuarine organic and inorganic matter and on the runoff to the coastal zone. In order to evaluate there influence on the shelf waters, an oceanographic expedition, on board R.V. Victor Hensen, took place from February to March, 1995. During this cruise, 68 stations distributed along 14 coastal normal profiles close to major mangrove systems of NE Brazil were sampled. Work included realization of vertical profiles of temperature, salinity and pH from surface to the bottom or for the top 400m. Water samples were retrieved with a 12 L Van Dorn bottle at three depths (surface, intermediate and near bottom) for stations shallower than 50 m and at 0, 50, 100, 150 and 200m depth for the remaining stations. Water sub-samples were analysed for content of dissolved oxygen and nutrient salts (N-NH_3, N-NO_2, N-NO_3, P-PO_4 and Si-SiO_2). The data subset relative to the region of Itamaracá Island (2 profiles with 5 stations each) is here discussed. The Tropical and the South Atlantic Central are the two water masses present at the area, corresponding respectively, to the layers above and below the thermocline at the three more oceanic stations. A pycnocline and the permanent thermocline are located between the depths of 100 and 300m and at the three more oceanic stations. The top 50-60m layer is well mixed, with temperature of 26.2 to 29.0°C and salinity between 36.6 and 37.8 ppt. A subsurface maximum salinity is present at a depth of 30-40m at stations offshore. Near the coast, the Tropical Water is found along the entire water column and water temperature is 0.5-1.0°C higher than that at four more oceanic stations. Dissolved oxygen were higher at the surface and at levels of saturation. pH varies from 7.6 to 7.8 at surface layer, reaching values of 9.5 at the 400m layer. Nutrient salt concentrations were, in general, lower at the surface and maximum just below the thermocline. Nitrite were below detection levels for most stations while nitrate ranged from 0.017 to 2.807 $\mu mol{*}l^{-1}$. Phosphate -P concentrations were low at surface and higher at the 100-200m layer, with values greater than 1.100 $\mu mol{*}l^{-1}$. Larger silicate concentrations were found near the surface, with values of 10.705 $\mu mol{*}l^{-1}$.

II. Phytoplankton composition and biomass

F. do N. Feitosa (UFPE), M. L. Koening (UFPE), R. Sassi (UFPB), G. F. Moura (UFPB)

Phytoplankton samples were collected at Catuama and Orange profiles (Itamaracá -PE) by the Oceanographic RV Victor Hensen for qualitative and quantitative studies. Qualitative analyses were based on samples collected with a plankton net (64µm) preserved with neutralized 4% formaldehyde and analysed under a standard microscope. Quantitative data were based on cell numbers and chlorophyll-a. Samples for cell counts were preserved with Lugol solution and analysed under an inverted microscope according to Utermöhl method. The samples for chlorophyll-a were collected with a Van Dorn bottle at different depths at the continental shelf: surface, middle and bottom layers and at the oceanic region: surface, 50, 100, 150 and 200 meters. The samples were fractionated in microphytoplankton (>20µm) and nanopicoplankton (<20µm) and analysed by the fluorimetric method.

A total of 100 species were identified among three taxonomic groups: diatoms with 51 species and 1 variety outranking the species: *Streptotheca thamensis*, *Rhizosolenia imbricata* var. *shrubsolei*, *Rhizosolenia styliformis* and *Asterionella notata*; dinoflagellates with 45 species and 1 variety being *Ceratium massiliense*, *Ceratium tripos* and *Ceratium vultur* var. *vultur* the most abundant; and among the cyanophyceans (2 species) predominated *Oscillatoria erythraeum*. A fourth group of unidentified nanoplanktonic flagellates (phytoflagellates) was also registered. In the coastal region, the diatoms and phytoflagellates were quantitatively the most important groups while in the oceanic region predominated the cyanophyceans. The cell density ranged from a minimum of 50,000 cells/l (station 38) to 590,000 cells/l (station 33). The chlorophyll-a horizontal distribution decreased from coastal (0.34mg.m-3) to oceanic stations (0.01mg*m-3). The vertical distribution at the coastal area increased from surface to the bottom layer while in the oceanic area the maximum chlorophyll-a occurred at 100m depth, close to the limit of the euphotic zone. The highest chlorophyll-a amount was obtained with the fraction < 20μm.

III. Phytoplankton production measurements

A. Stuhr (IfMK)

Primary production of phytoplankton is dependent upon light, CO2 and nutrients. In oligotrophic areas nutrients become limiting. In general, higher primary production is expected in eutrophic areas than in oligotrophic areas. According to the grade of pollution along the coast of Northeast Brazil differences in phytoplankton production and community were expected to be found.

The investigations were done on 14 transects along the north-east coast of Brazil. During the first half of the cruise each transect started at the coastal station, on the second half at the oceanic station. *The production measurements were made always on the first station of each transect.* The oxygen method was used for measurement of primary production. The oxygen concentration in the dark and light bottles were determined with the help of the Winkler method (1888) (automatic titration system). The prefiltered (100 or 200 μm) samples were filled into Nalgene and glass bottles.The samples were incubated for 6 hours in a basin (80 x 60 cm) on the ship containing seawater of in-situ temperature (ca. 30 °C). The depth of the samples was simulated by light filters. Filters with 0.1, 1, 10, 20, 30, 50 % light penetration were available. Because of technical problems, on station 19, 25 and 31 all samples were taken from the surface and incubated under different light conditions.

In the Nalgene bottles the production rates seemed to be generally lower than in the parallel incubated glass bottles. The necessity of transferring the sample from Nalgene into glass bottles for the final

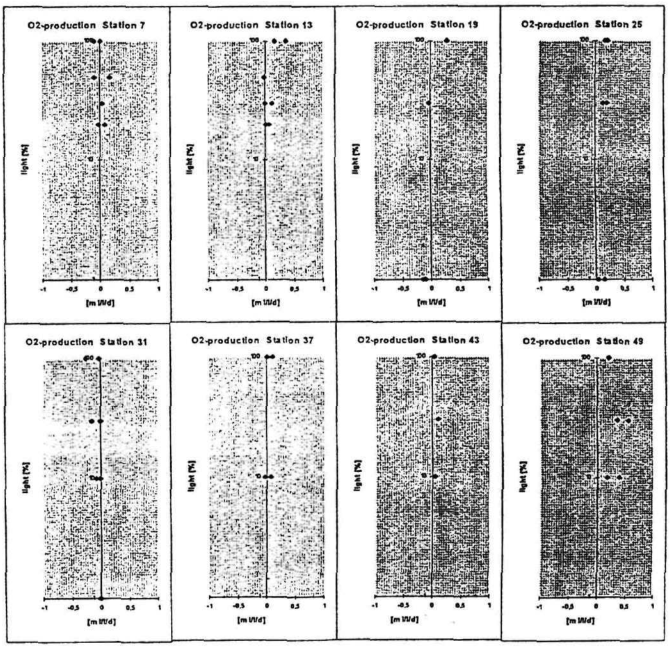

Fig. 1: Oxygen production at selected stations at different light intensities during JOPS II-5

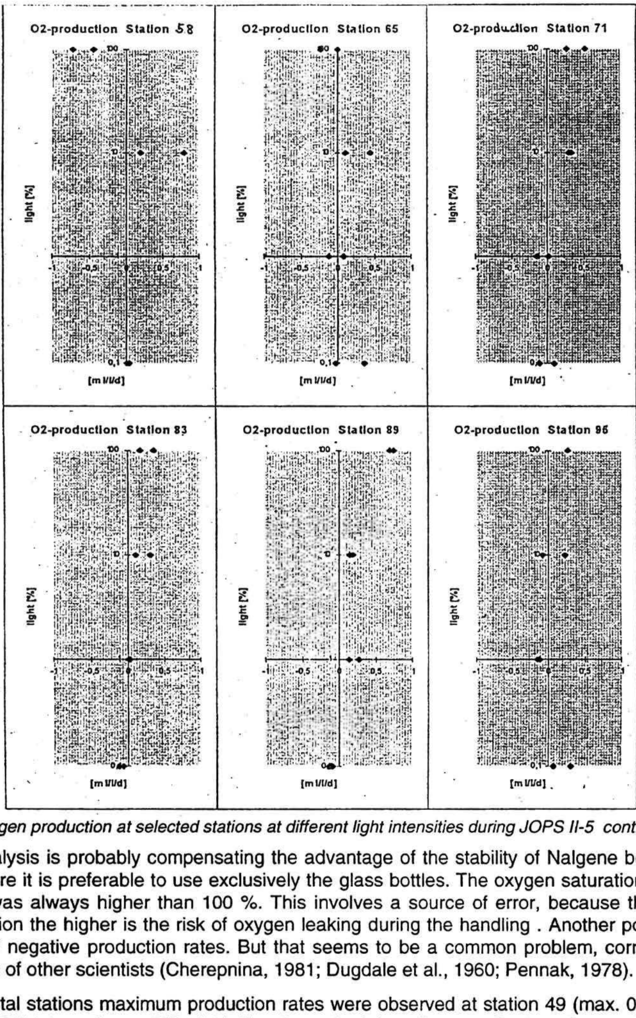

Fig. 1: Oxygen production at selected stations at different light intensities during JOPS II-5 cont.

oxygen analysis is probably compensating the advantage of the stability of Nalgene bottles. Therefore, in future it is preferable to use exclusively the glass bottles. The oxygen saturation of the tropical water was always higher than 100 %. This involves a source of error, because the higher the oversaturation the higher is the risk of oxygen leaking during the handling . Another point is the occurrence of negative production rates. But that seems to be a common problem, corresponding to the findings of other scientists (Cherepnina, 1981; Dugdale et al., 1960; Pennak, 1978).

At the coastal stations maximum production rates were observed at station 49 (max. 0,56 ml O_2/l/d, i.e. 150 µg C/l/d, based on a P/Q of 2) (fig. 1), north of Joao Pessoa. On the other stations in general the production did not exceed 0,2 ml O_2/l/d (i.e. 55 µg C/l/d). In the oceanic area the highest production rates were measured on station 89 (max. 0,75 ml O_2/l/d, i.e. 200 µg C/l/d) (fig. 2), while the other values were around 0,2 to 0,3 ml O_2/l/d (i.e. 55 to 80 µg C/l/d).

Comparing the coastal and oceanic stations, no prominent differences were observed. If at all there is a general difference between the two areas, the values of the oceanic stations seemed to be slightly higher. Perhaps this can be due to a shading effect caused by a higher sediment content in the coastal water. Further, the higher amount of zooplankton in the coastal areas can reduce the oxygen production. Nevertheless, it is difficult to distinguish between significant differences of the production rates and variability due to methodical error. The primary production values did neither correlate with the in-situ fluorescence, nor to microscopical observations of the net catches. Therefore, for the interpretation chlorophyll data could be most helpful. Conclusively, I want to point out that the oxygen method to my opinion is not very suitable for primary production measurements in tropical regions. Firstly, this method is not very sensitive, in respect to low production rates. Secondly, the tropical water is usually oxygen oversaturated. That means, in this case it would probably be better to use the ^{14}C-method of Steemann Nielsen (1952).

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IV. Microzooplankton diversity and production

S. Neumann-Leitão (UFPE), L.M. O. Gusmão (UFPE), T. A. Silva (UFPE) & D. A. Nascimento-Vieira (UFPE)

The zooplankton community structure of Northeast Brazil was investigated to verify the mangrove influence on the productivity and diversity in the coastal waters. Microzooplankton samples were collected from latitudes 2° to 9°S, in 70 stations located in 15 profiles perpendicular to the coast. Small Bongo nets with 64 and 120µm mesh size were used.

The total biomass was determined for all samples by the wet weight method. Qualitative and quantitative analysis were carried out for profiles number 7 and 8 off Itamaracá, where an intensive research program on the estuarine ecosystem already exists and results will be compared with later on. The total biomass for the 64 and 120 µm mesh size varied from 0.52 mg*m^{-3} to 15.03 mg*m^{-3} and from 0.74 mg*m^{-3} to 8.2 mg*m^{-3}, respectively.

Higher values were found in coastal stations off Recife (8°02'), Itamaracá (7°42') and Fortaleza (4°28') profiles. Zooplankton (120 µm mesh size) in the Itamaracá area represented 84 taxa outranking Copepoda with 32 species. The most common were *Undinula vulgaris, Nanocalanus minor, Scolecithrix danae* and *Eucalanus pileatus.* The zooplankton community is composed by tropical, shelf surface and Brazil Current species. The low zooplankton quantity indicates an oligotrophic water mass, enriched punctually by the mangrove nutrients. High diversity (> 3.0 bits*ind^{-1}) can be explained by the spatial stability.

V. - Macrozooplancton community structure and isotopic composition

R. Schwamborn (ZMT), M. Voss (IOW), W. Ekau (ZMT), W., U. Saint-Paul (ZMT)

General objectives

The main objective of the study was to quantify the export of plankton organisms and POM from mangrove areas to the northeastern Brazilian continental shelf. Mangroves are widely recognized as nursery areas for fish and invertebrate stocks (Robertson and Duke 1987; Vance et al. 1990). Some decapod species do export their larvae from the estuaries, probably to avoid predation (Morgan, 1990). The knowledge about the distribution of exported meroplankton in coastal areas, and the mechanisms involved in larval dispersion on the continental shelf, is however still very fragmentary.

In the western equatorial Atlantic, the near-surface-circulation is dominated by the South Equatorial Current (SEC), which divides into two branches: the North Brazil Current (NBC), which flows to the north-west, and the Brazil Current (BC), which flows to the south. While oligotrophic SEC waters come in contact with the coastal boundaries, fertilization may take place through export of nutrients, organic material, and organisms from coastal ecosystems. To assess the influence of mangrove-dependent meroplankton on the shelf plankton community, the biomass and taxonomic composition of the shelf plankton and neuston was analyzed. Furthermore, stable carbon isotope ratios ($\delta^{13}C$) from POM and the tissue of shelf zooplankters were measured to verify wether POM from mangrove areas is exported to the shelf and wether it enters neritic food webs.

Zooplankton biomass and composition

Objectives

The aim of this project was to analyze the biomass distribution and community structure of the shelf macrozooplankton. The distribution of meroplankton organisms can provide information on larval transport between mangrove, coastal and offshore waters.

Methods

For the assessment of the macrozooplankton, vertically integrating Bongo hauls were made at 14 transects along the northeastern Brazilian coast (fig. 1). Sampling depth was between 14m (nearshore) and 150m (offshore). Mesh sizes employed were 300 and 500µm, net diameter was 60 cm.

Samples for taxonomic and biomass studies were immediately conserved in buffered 4% formaline. In the laboratory, total biomass of all catches was estimated by wet weight. To describe the community structure of the macrozooplankton, 12 stations off Pernambuco State and 9 stations off Ceará State were chosen. Organisms found in those samples were sorted into 44 taxonomic groups. For a first classification of develop-

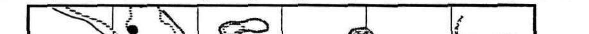


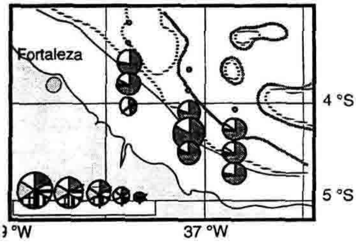
Fig. 2: Biomass distribution in the 500µm-Bongo-hauls during JOPS-II-5.

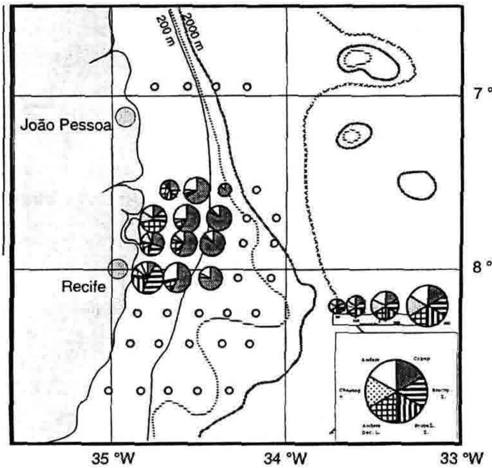
mental stages, brachyuran zoeae were sorted into early and late stages. Early stages were recognized by the absence of pleopods.

Results

The total biomass of the 300µm catches varied betweeen 16 and 188 mg/m3, with an average of 63 mg/m3. Both nets, 300 and 500µm, show similar distritution pattern. Therefor at this place only 500µm-catches are shown (fig. 2). The biomass distribution in the southern transects (south of 7°40'S) is conspicuously different from the nortwestern transects (east of 36°W). The plankton biomass shows nearshore maxima in the the southern area, off Pernambuco State. At the 3 nortwestern transects, off Ceará State, coastal biomass maxima do not occur. In the intermediate areas, both biomass distribution patterns occur.

At almost all transects, the outermost oceanic stations show very low biomass values (<50 mg/m3). Such low plankton biomass values are typical for oligotrophic waters originating from the SEC.





The Zooplankton community structure shows a clear shoreward gradient at the 4 transects off Pernambuco State (fig.3). At all 4 transects, the abundance of decapod larvae is highest at the most nearshore stations and decreases abruptly towards the shelf edge. Among decapod larvae, brachyuran and porcellanid zoeae are the most abundant taxa at the nearshore stations (fig.3). At the most offshore shelf stations, copepods dominate by abundance.

Fig. 3: Zooplankton composition in the 300µm-Bongo-hauls during JOPS-II-5 on the northern transects off Ceará (left) and off Pernambuco (above)..

Since extremely high abundances of brachyuran and porcellanid zoeae are typical for mangrove esuaries (Dittel & Epifanio, 1990, Robertson et al., 1988), the community structure pattern described above indicates that there is a considerable export of zooplankton from mangroves to nearshore shelf waters in the Pernambuco State area. This export is limited to a coastal parallel band, approximately 10-20 km broad.

At the transects off Ceará State, there is no obvious shoreward gradient in the community structure (fig.3). Copepods and other holoplanctonic organisms dominate at all stations.

Results from biomass determination as well as community structure studies indicate that there is a strong effect of mangrove ecosystems on nearshore shelf plankton off Pernambuco whereas in the Ceará area no such effect could be identified. This difference could be due to larger mangrove areas at the Pernambuco coast. On the other hand, differences in meso- and large scale current patterns in both areas possibly result in a stronger influence of SEC waters at the shelf off Ceará State. Water masses at the shelf stations off Pernambuco State have possibly come in closer contact with coastal boundaries.

POM and Zooplankton isotopic composition

Objectives

In recent years stable carbon isotopes have been used to trace marine food webs, since the $\delta^{13}C$ of an organism closely reflects the stable isotope ratio of its food source (Forsberg et al., 1993, Fry & Parker, 1979, Fry & Arnold, 1982, Harrigan et al. 1989). Since an export of organic matter from mangrove estuaries to coastal waters may take place in the study area (Rezende et al., 1990), stable isotope ratios of zooplankton were measured to verify wether mangrove carbon enters coastal pelagic food webs. To identify POM exported from mangroves, Seston samples were mesured for their $\delta^{13}C$ too.

Methods

Macrozooplankton samples for isotope measurements were collected at 26 stations during leg 5. For a first assessment of stable carbon isotope ratios, samples from 6 stations off Pernambuco (transects 6 and 7) have been analyzed as yet. The mesh sizes employed were 300 and 500µm, net diameter was 60 cm. Additionally, surface water samples were collected at 17 stations at Pernambuco State and Ceará State waters. 16 to 20 l of surface water were filtered through pre-combusted glassfiber filters to obtain POM samples. All samples were immediately frozen on board at -70° C.

Subsamples from the plankton catches were taken ad libidum for isotope analysis and dried. Furthermore, 6 taxonomic groups of organisms were sorted and analyzed separately. Each group comprised 10 to 40 individuals, according to approximate individiual biomass. All isotope samples were rinsed with distilled water and dried at 60-70°C for at least 24 hours. Subsamples of 0.7 to 1.8 mg dry weight were acidified with HCl and dried. Finally, the carbonate-free subsamples were combusted and analyzed for their $^{13}C/^{12}C$ ratio using a gas isotope ratio mass spectrometer. The ^{13}C values are referred to as ‰ deviation from PDB limestone.

Results

The isotope measurements provide first information on the influence of mangroves on the northeastern-Brazilian shelf (tab. 1).

The $\delta^{13}C$ values of zooplankton tissue are conspicuously heavier (higher $\delta^{13}C$) than the POM (tab. 1, fig.4). This difference has proved to be significant at α=0,01. Since the POM has to be assumed to be the primary carbon source for the zooplankton community, the accumulated assimilatory isotopic shift can be estimated as follows:

$$-18.47 \text{‰ PDB} + 23.22 \text{‰ PDB} = -4.75 \text{‰ PDB}.$$

Tab. 1: $\delta^{13}C$ values of zooplankton and seston (POM) samples taken during leg 5 in May 1995. 31 samples have been measured.

Stations	Compartment	$\delta^{13}C$ (mean)	Shelf Area	Number of Samples
31, 32, 33, 37, 38, 39	**Zooplankton**	-18.47 ± 0.26	Pernambuco	14
29, 31-33, 37-39, 79-81, 85-87, 91, 93	**POM** (all samples)	-23.22 ± 0.28	Pernambuco and Ceará	17
31, 37, 79, 85, 91	**POM** (only nearshore)	-22.34 ± 0.93	Pernambuco and Ceará	7
29, 33, 39, 81, 87, 93	**POM** (only offshore)	-24.45 ± 0.96	Pernambuco and Ceará	6

Isotopic values measured in POM samples from the shelf areas off Pernambuco State (N=9) and Ceará State (N=7) were not significantly different (α =0,05).

However, there are clear differences in POM isotopic composition between nearshore and offshore stations (tab. 1, fig.4). The 7 nearshore stations showed significantly (α =0,01) heavier values than the 6 offshore stations (> 40 km from the coast). An increase in $\delta^{13}C$ towards the coast can also be found in the isotopic values of the zooplankton and POM samples taken off Pernambuco (fig.4).

POM in local mangrove ecosystems shows $\delta^{13}C$ values around -25 ‰ PDB (Schwamborn, unpubl.

data), *much lighter than those* found at the shelf stations. If there was a measurable export of *organic matter from mangrove are*as, the nearshore POM $\delta^{13}C$ should be lighter than offshore. *Therefore, it must be assumed* that in both areas (Pernambuco and Ceará) mangrove POM does *not contribute significantly to shelf* waters.

Accordingly, the $\delta^{13}C$ values of zooplankton varied between -16,3 and -19,8 ‰ PDB (Tab. 2). Those values are typical for trophic systems based on phytoplanktonic production (Matsuura & Wada, 1994).

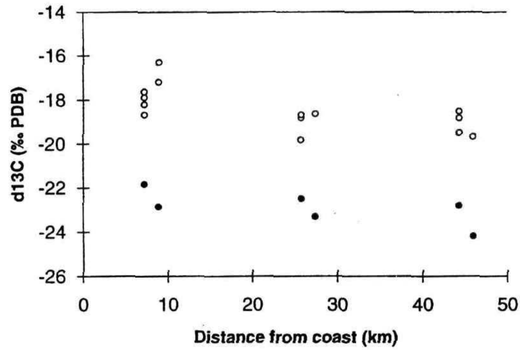


Fig. 4: $\delta^{13}C$ values measured in POM (•) and zooplankton samples (o) taken at the continental shelf off Pernambuco State, Brazil. Samples were taken at the stations 31-33 and 37-39 (JOPS II, leg 5) in May 1995.

Tab. 2: $\delta^{13}C$ values of zooplankton samples taken during leg 5 in May 1995.

Station	**Taxonomic group**	**Number**	**$\delta^{13}C$** (‰ PDB)	**Dist. from coast** (km)
32	Subsample	-	-18,84	28
33	Subsample	-	-18,85	46
37	Subsample	-	-16,30	10
38	Subsample	-	-18,66	30
39	Subsample	-	-19,69	49
31	Copepoda	40	-18,68	8
32	Copepoda	30	-18,71	28
33	Copepoda	30	-19,52	46
31	Chaetognatha	15	-17,63	8
33	Chaetognatha	10	-18,54	46
31	Brachyura, Zoeae	15	-17,89	8
31	Brachyura, Megalopae	10	-18,20	8
32	Lucifer sp.	2	-19,84	28
37	Porcellanidae, Zoeae	10	-17,20	10

Thus, the organisms measured in this study did not feed upon food chains based on mangrove detritus. *The difference in* $\delta^{13}C$ *between copepods and chaetognates lays between* -1,05 and -0,98 ‰ PDB. This result suggests a ^{13}C shift of about -1 ‰ PDB per trophic level occurring in pelagic food webs.

Preliminary conclusions

In contrast to the results of the community structure and plankton biomass studies, the isotope data do not at all suggest an export of POM from the adjacent mangroves in May 1995. The export of larval organisms (to be confirmed by accurate taxonomic identification) in contrast to the absence of mangrove POM on the shelf could only be explained by active transport mechanisms. Those larvae would thus possibly be exported to the shelf by vertical migration in phase with tidal currents.

The high difference in ^{13}C between macrozooplankton and POM, both nearshore and offshore, hints at the importance of "microbial loops" and intermediate consumers between those compartments.

Acknowledgements

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VI. Ichthyoplancton distribution and community structure

W. Ekau (ZMT), P. Westhaus-Ekau (ZMT)

Objective

The Northeast Brazilian coastal waters are dominated by the oligotrophic Brazil current system. The generally low productivity in this area is increased only by local upwelling events, caused by seamounts, islands or oceanic banks.Another source for nutrient increase is a number of medium sized rivers with a greater or smaller export of nutrients and sediments. By this coastal ecosystems, at land and sea, influence each other and may have strong interrelations or interactions, respectively.

Fish communities, which locate their habitat within this zone, benefit from these physical interactions by using the higher productivity for their own nutritional needs. Many species in shallow coastal waters are in exchange with ecosystems like mangrove forests or river estuaries. They use these areas as refuge for their young stages and as feeding grounds at all sizes. It is an accepted hypothesis, that mangrove forests influence the productivity of coastal waters, and with this also the biomass production of commercially important organisms. First estimates of the amount of contribution, mangroves support to coastal fisheries, have been made. Krishnamurthy (1984) has calculated, that Indian mangrove-estuary-fishery contributes about 30,000 t of fish and 130,000 t of shrimps to the total catch. After him, about 60% of the Indian coastal marine fisheries depends on species, which use mangroves as nursery ground. Macintosh (1983) gives an example for Malaysia, where mullet catches decreased from 2,859 t in 1969 to 431 t in 1975. He explains this decrease with the drastic degradation of mangrove forests in the same period. Turner & Boesch (1987) found a correlation between landings of penaeid shrimps and mangrove areas with a coefficient between 0.62 to 0.97, and Whitten et al. (1984) estimated, that the loss of 1 ha of mangrove forest would induce a decrease of 480kg in the landings of fish or shrimps.

It is, however, not yet fully understood, how and to which amount mangroves really contribute to the productivity of coastal marine fish stocks.

The works done during the 5th leg of JOPS-II have been designed to collect data and material in the framework of the objective described above. The works are connected to a cooperational project, that was and is carried out in a mangrove estuary north of Recife, where intensive studies are done on the inventory, abundance and distribution of relevant fish and crustacean species. Besides the first comprehensive description of the ichthyoplankton fauna along the Northeast Brazilian coast, the link to the estuarine plankton communities in the Itamaracá region is the main goal of this study and analysis of samples was concentrated on this objective first.

Methods

A total of 115 samples were collected for the analysis of fish larvae distribution. Mesh size used was 500 µm. The nets were mounted in a Bongo frame (71 hauls), and to catch the fish larvae at the surface, in a Neuston-sledge frame (44 hauls). Catching depths for the Bongo net hauls were from surface to 5 m above the bottom or down to a maximum of 212 m. The upper Neuston net swapped the upper most 10 cm surface layer, the lower net caught in a depth range from 15 to 30 cm.

Every transect has been worked up during one day, starting in the morning one hour before low tide at the nearshore station, then working towards the open ocean. After the fifth station, the ship returned to the nearshore station of the next transect to start there again in the next morning. By this tidal influence on nearshore samples has been avoided. The transects had been located in front of river mouths, in some cases connected with mangrove areas, in others with urban installations like cities or ports (e.g. Recife or Suape).

The samples were conserved immediately after the catch in 4% formalin. In the laboratory of the Center for Tropical Marine Ecology in Bremen, biomass was determined as wet weight and standardized into mg/m^3. The samples were transferred subsequently into a preservation fluid consisting

Fish larvae / 50 m3, Transects 2 to 9	Bongo 500	Neuston upper	Neuston lower
x	35,58	16,80	2,17
s	17,87	22,53	3,38
cv = s/x	0,50	1,34	1,56
min	10,59	0,00	0,00
max	77,34	100,23	14,56

Fish eggs / 50 m3, Transects 2 to 9	Bongo 500	Neuston upper	Neuston lower
x	14,18	39,78	24,42
s	25,27	46,29	25,73
cv = s/x	1,78	1,16	1,05
min	0,00	0,00	0,58
max	131,32	169,53	100,69

Tab. 1: Total numbers of fish larvae and eggs in the different net catches of transects 2 to 9 (Pernambuco area). Given values are: x = arhythmetic mean, s = standard deviation, cv = coeff. of variance, minimum and maximum values.

of propylene phenoxetol (0,5%), propylene glycol (5%) and water (94.5%) and analysed for species composition and abundance. First analysis of samples concentrated on day catches from transects 2 to 9. Maximum catching depths on these transects was 150 m. From the Neuston samples, catches from the upper net were chosen. Biomass and number of organisms in lower net catches were significantly smaller (tab. 1), and in many cases to small to give significant results in species composition.

Results

Neuston

During the day, abundance of fish larvae in the upper surface layer from transect 2 to 9 was generally low (see tab. 1). Slightly higher concentrations could be observed on the continental shelf, where two stations became prominent: station 19 off Rio Pirapema and station 50 off Rio Paraíba; 100 or 65 fish larvae per 50 m^3 have been found, respectively.

The fish eggs were obviously concentrated at nearshore stations down to 200 m water depth with highest amounts at the southern transect number 2 (about 170 eggs/50 m^3). During the investigation period, the eggs were more widespread than the later developmental stages, i.e. larvae and juveniles.

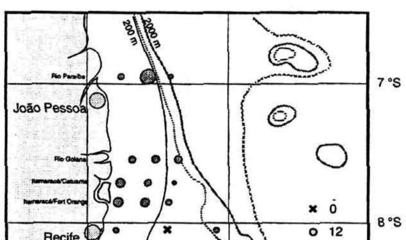

Fig. 1: Distribution of fish larvae in Neuston catches (upper net) during JOPS-II-5. Circle areas represent numbers per 50 m^3.

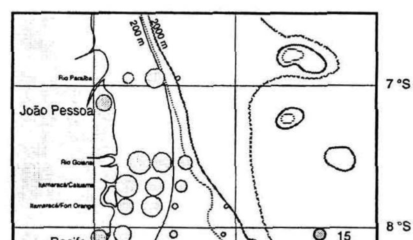

Fig. 2: Distribution of fish eggs in Neuston catches (upper net) during JOPS-II-5. Circle areas represent numbers per 50 m^3.

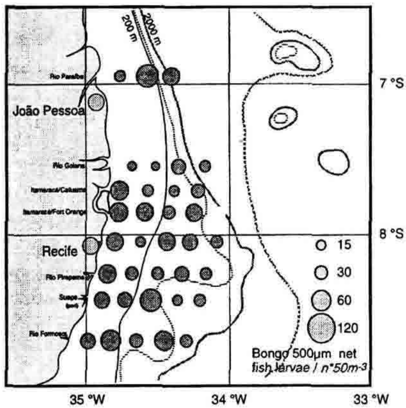

Fig. 3 Distribution of fish larvae in Bongo catches during JOPS-II-5. Circle areas represent numbers per 50 m^3.

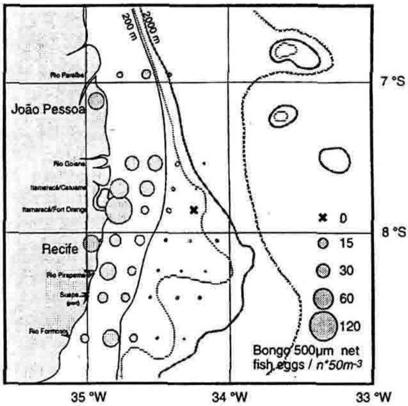

Fig. 4: Distribution of fish eggs in Bongo catches during JOPS-II-5. Circle areas represent numbers per 50 m^3.

Bongo

The fish egg abundances of the integrating Bongo hauls showed similar pattern to the Neuston surface distribution (fig. 4). The eggs were concentrated on the shelf, highest values, however, were observed in front of the Itamaracá channels with 131 and 57 eggs per 50 m^3, respectively.

Fish larvae showed a very homogeneous distribution pattern with concentrations between 11 and 77 specimens per 50 m3 (fig. 3; see also tab. 1 for coefficient of variance). Higher values were found also at offshore stations regularly.

The fish larvae community of three stations in front of the southern Itamaracá channel mouth have been analysed taxonomically. These stations have been chosen to test the assumption about interactions between the mangrove forest in the channel and the adjacent coastal zone. A cooperative project between the University of Recife and the Center for Tropical Marine Ecology has worked on the ecology of this estuary.

The taxonomic identification given in tab. 2 is preliminary because of limited individual numbers and low degree of development of most of the larvae in the catches worked up. In total 33 different taxa could be determined. Although there were found similar concentrations of larvae at the three stations (38, 45 and 28 larvae per 50 m^3, respectively), it is obvious that there was a shift in the taxonomic composition from nearshore station 31 to offshore station 33 (tab. 2). Station 31 was dominated by shallow water taxa, such as blennnioids, microdesmids (wormfishes) -both are benthic as adults- and anchovies (Engraulidae), which appear in shallow waters and in estuaries as well. Adult demersal gobies, whose larvae were dominating too, prefer both, nearshore habitas and areas of lower salinities as river estuaries.

Most specimens caught at station 32 were snappers (Lutjanidae), parrotfishes (Scaridae) and gobies (Gobiidae). Snappers are benthic fishes, occasionally found in estuaries too. Adult and juvenile parrotfishes are mainly associated with coral reefs. At station 33 more oceanic taxa were observe such as lanternfishes. Overlapping of the communities at station 32 and 33 are more evident than at stations 31 and 32.

Comparing the length distribution of all larvae at these three stations, an increase in size from the coast to oceanic region could be noticed.

Preliminary conclusion

Hydrographical reasons for the distribution pattern of the ichthyoplankton cannot be put forward at the moment, because water temperature in the upper 5 m have been almost constant (between 27.7 and 29.0 °C), and also in deeper layers no significant patterns could be observed. It has to be waiten for the final analysis of the hydrographic data. The influence of water currents in the investigation area is not yet proved, too.

Considering the coastal structure in the investigation area it is assumed that mainly the higher fish-egg concentrations as well in the upper surface layer as in the water column were associated with the position of river estuaries, which are fringed by more or less expanded mangrove forests: coastal stations on transect 2 were placed off the river Formoso estuary, transect 4 was started off the river Pirapema. Transect 6 and 7 were placed in front of the Itamaracá channel mouths, where mangrove forest is more guarded to the coast similar as off Rio Paraíba.

In comparison with these estuaries, lower abundances were recognised at stations on transects 3 and 5, where nearshore plankton communities were possibly influenced by impacted harbour areas as Suape and Recife.

Comparing these first results of the coastal ichthyoplankton community with the comprehensive investigated fauna in the Itamaracá channel, it can be stated, that the larval diversity is high at both locations, but that the composition is very different. The dominating larvae in the channel such as anchovies and gobies, were also observed at the coastal stations, but it is assumed that they belong to different taxa. This holds at least for the gobies.

Therefore at the moment there is no evidence to suppose an active movement or drift of single larval taxa by tidal currents into or out of the channel,which reaches until the nearshore stations of the transects.

Tab. 2: Taxonomic composition of the three Bongo day catches at stations 31, 32 and 33.

Station	31	32	33
Haul	21	22	26
catch depth / *m*	10	30	47
water depth / *m*	18	42	600
Blennioidea	5,8		
Spariidae-type	5,8		
Microdesmidae	2,9		
Engraulidae	2,9		0,6
Gobiidae	2,9	5,2	0,6
Clupeidae	2,2		
Perciformes indet.	2,2		
Aluterus sp.	1,5		
Scorpaeniformes	1,5		
Spoeroides sp.	0,7		
Tripterygiidae	0,7		
Cottidae	0,7		
Doratonotus megalepis	0,7	1,4	
Carangidae	0,7	0,5	
Lutjanidae		5,2	
Scaridae		4,7	2,9
Monacanthidae		2,4	
Lampanyctinae		2,1	
Nomeidae		1,4	1
Spyraena borealis		1,4	
Diodontidae		1,4	
Fistularia sp.		0,5	
Anthiinae		0,5	
Rypticus sp.		0,5	
Ophiidiformes		0,2	0,3
Ioglossus sp.		0,2	
Opistognathidae		0,2	
Scombridae		0,2	
Bothus sp.			1,3
Myctophinae			0,6
Thunnini			0,3
Nesiarchus nasutus			0,3
Symphysanodon sp.			0,3
indet.	6,6	17,5	16,7
Σ	37,8	45,5	24,9
total larvae counted	*52*	*193*	*78*

Acknowledgement

We are grateful to all people who helped to carry out this work: our Brazilian colleagues for the good cooperative work aboard Victor Hensen, the crew for the technical assistance and the students who helped sorting the samples.

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Leg 6: Geological and biological investigations of late Quaternary processes off Northeast Brazil

Chief scientists: Dr. M. Tintelnot (FIS), Prof. J.O. Morais (UFCE)

Cruise report

Introduction and objectives

Project JOPS-II leg 6, executed on the "VICTOR HENSEN" from the Alfred-Wegener-Institute, Bremerhaven, involves co-ordinated research groups from Brazil and the Federal Republic of Germany. Participants are the Geological Department of the University Fortaleza/Ceara, the Labomar (Fortaleza) and the Department of Oceanography of the University of Recife/Pernambuco in the former case, and the Department of Marine Research of the Senckenberg Institute, Wilhelmshaven, and the Geological Department of the University of Bremen in the latter case. The main aim of this expedition consists in collecting samples and following investigations for sedimentological, mineralogical, geochemical, micropaleontological, isotopic, geophysical and biological research.

In the course of the voyage from Fortaleza to Recife, samples were taken from offshore areas off the mouths of the Jaguaribe, Apodi, Acu, Potenji, Mamanguape and Paraiba rivers, as well as from the entire NE-Brazilian continental slope and the adjacent Pernambuco Plateau (Fig. 1). Detailed analyses of sediments, suspended matter and water from the continental margin, rivers and mangroves can provide information on material sources, transport and final deposition processes. Studies of sediment cores, amongst other things, can provide evidence of former marine/terrestrial conditions in relation to sea-level changes, of land-derived material and of current activity along the continental margin during the Late Pleistocene.

Along transects crossing the continental shelf, the shelf edge and the upper continental slope at water depths of 20 m, 60-80 m and 200 m close to the mouths of the Jaguaribe, Mossoro, Acu, Touros, Potenji, Cunhau, Paraiba rivers and north of Recife, dredges were used for the collection of biological material (Fig. 2). Furthermore, the seabed of the rivers Jaguaribe and Agu was surveyed by sediment-echosounder and side-scan sonar.

Originally, a shallow seismic survey of the Ceara coast was intended. However, the capacity of the available boomer was too low to obtain reliable data. In addition, technical failure prevented further use of the instrument.

Cruise objectives of JOPS-II leg 6 were:

- to investigate Late Quaternary development of paleochannels in relation to paleoclimatic fluctuations in river drainage basins in terms of geophysical, sedimentological, mineralogical, geochemical and isotopic parameters on the NE-Brazilian coastline, mainly using geophysical and coring equipment along shallow offshore areas off several river mouths;

- to retrieve cores (max. 6 m long) from the upper slope (500 - 1000 m water depth) of the entire study area to reconstruct the Late Quaternary development of the North Brazil Current by micropaleontological, sedimentological, mineralogical, geochemical and isotopic analyses;

- to study the distributions and living conditions of benthic species in water depths of 20, 60-80 and 200 m using dredges and CTD;

- to sample suspended matter and surficial sediments by different sampling techniques from shallow shelf stations (8 - 25 m water depth) near mangrove areas and above mentioned river mouths, in order to determine recent input of riverborne suspension loads by means of geochemical and mineralogical analyses;

- to conduct side-scan sonar and seismic surveys parallel to the coast in inner to middle shelf regions off river mouths, especially for the rivers Jaguaribe, Apodi and Açu, in order to investigate the relationships between organisms and substrate on the one hand and on the other hand to estimate the abundance of non-living calcareous algal substrate which would be of regional economic importance for any future exploitation for the cement-portland industry.

Study area

The study area is situated between 4° to 8°S and 34° to 39°W and is characterized by high variability in shelf width which ranges from almost 100 km near Fortaleza in the NW to about 15-30 km between Natal and Recife in the southern part. In addition, the upper slope is steep and narrow. Morphological structures are mostly determined by faults, especially in the vicinity of the Jaguaribe (Potiguar Basin) area. The slope is interrupted by the Pernambuco and Rio Grande plateaus, which have relatively smooth, gently sloping surfaces 500-2500 m deep. Only the Pernambuco Plateau was sampled. The continental shelf is mostly shallower than 40 m, except northwest of Natal where much of it is shallower than 20 m while its edge is about 60-70 m deep.

Carbonate sediments, composed primarily of reef and coralline red algae debris, dominate the entire shelf of Ceara. Sedimentation on the narrow and shallow NE-continental shelf reflects the source geology, climate, drainage and tectonic setting. Partly tropical climate along a narrow coastal belt as well as arid hinterland conditions, resulting in negligible terrigenous sedimentation, are responsible for the biogenic carbonates dominating most parts of the middle shelf and the entire outer shelf regions. These carbonate sediments are predominately recent calcareous algae, with Halimeda and branching corallines, at which most of them appear to be relict on the outer shelf, while those located on middle shelf areas seem to be modern. Terrigenous sedimentation is confined mainly to the inner shelf, especially off river mouths, dominated by terrigenous quarz sands with small amounts of mud. The rate of modern or recent terrigene detritus supply is very low and, because of that, terrigenous sediments are largely relict. Coastal erosion, affected by near-shore currents and waves, is responsible for the absent, most recent terrigenous sediment deposition on these shelf regions. Current and wave activities along this NE-Brazilian part of the continental shelf, also as lacking river sediment transport due to a carbonate-dominated shelf region.

The straight coastline is bordered offshore by beach rocks in parallel zones and also by several coast-parallel calcareous reef sandstones, some of which are cemented dune sands (eolian calcarenites).

The coastal area is dominated by the presence of the Barreiras Formation, which constitutes a flat surface at low altitude that reaches the coast where it has been reworked since Early or Middle Pleistocene times. For the greater part, these younger sediments overlie an eroded surface of Precambrian crystalline rocks, but in some places they are situated on Cretaceous sediments. The mountain ranges, with some outcrops of Proterozoic acid plutonic intrusives, are 500-1000 m high along the east coast. Between these ranges and the sea occurs a narrow coastal plain which is 50-60 km wide near Fortaleza, but narrows to 15 km between Joao Pessoa and Recife.

Variations in climatic and oceanographic conditions in this region are responsible for a geographic division into two parts. The northern part is exposed to a semi-arid climate. The coast is more or less straight and depositional, with beach ridges and sand dunes (some sandy beaches are backed by extensive dune fields) alternating with lagoons and salt marshes. Between Natal and Recife, under humid tropical conditions with annual rainfall of 1000 to 2000 mm and a lenghty dry summer season, the coast shows cliffs cut into the Barreiras Group and beach ridge plains with some sand dunes. These sand deposits, as well continental as marine in origin and marginally reworked by the wind, imply a climate slightly drier than that of the present-day. The evolutionary history of this part of the Brazilian coastline shows that sedimentation along the coastal zone was controlled fundamentally by the Quaternary sea-level changes, as well as being influenced by the Equatorial Current and the easterly trade winds.

Offshore, oceanic circulation is dominated by the two branches of the South Equatorial Current which impinge on the Brazilian coast between Natal and Salvador. During June to August the division of these two branches is most conspicuous, whereas between September and May the separation of the South Equatorial Current takes place far offshore of Natal to Recife. The northern

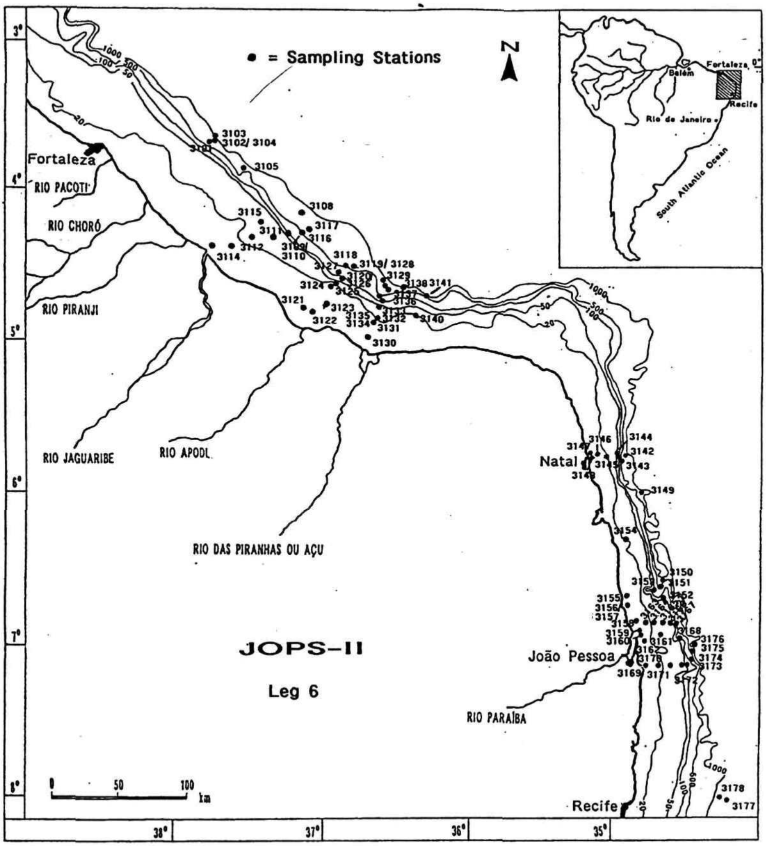

Fig. 1: Location map and sampling stations of the research area studied during VICTOR HENSEN cruise Leg 6

branch, the North Brazil Current, flows north and west along the coast at 1-2 knots, and gives rise to strong, northwestward longshore drift. The southern branch, the Brazil Current, flows south at about 0.5 knots, except in winter when there is a northly directed counter-current along the coast.

Equipment and sampling

The sampling took place from 13.03. to 26.03.1995 on the "VICTOR HENSEN", in an area extending from Fortaleza to Recife along the NE coast of Brazil. The route incorporated 9 profiles (see enclosed map) on the shelf and shelf margin along which sediment samples were taken, mainly using core equipments. Most important were offshore areas off river mouths.

Many sample locations were selected after a 18 kHz bathymetric survey on a depth profile ranging from the shelf edge (50-80 m water depth) to the upper slope (up to 1400 m water depth), which was carried out before sampling. However, internal sediment structures could not be detected by this equipment. Thus, important information on sediment features, such as thickness of the sediment cover, correlation horizons, erosional discontinuities, slumpings and trubidites were not available. Therefore, a boomer and side-scan equipment was used for some transects across the shelf.

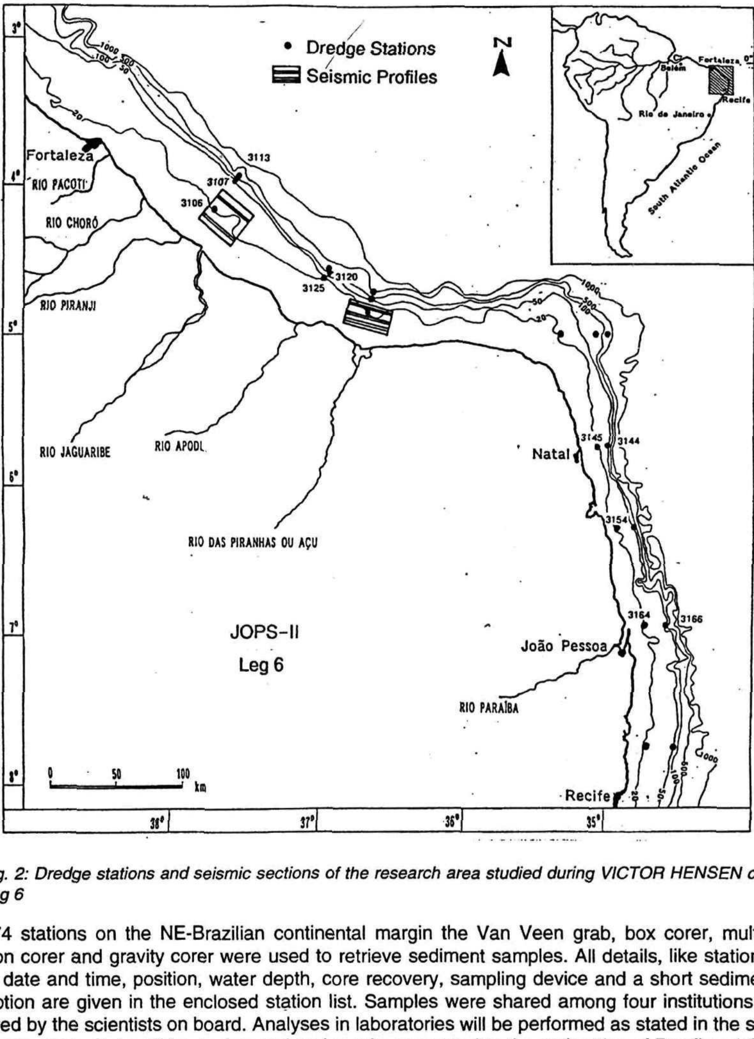

Fig. 2: Dredge stations and seismic sections of the research area studied during VICTOR HENSEN cruise Leg 6

At 74 stations on the NE-Brazilian continental margin the Van Veen grab, box corer, multicorer, piston corer and gravity corer were used to retrieve sediment samples. All details, like station number, date and time, position, water depth, core recovery, sampling device and a short sediment description are given in the enclosed station list. Samples were shared among four institutions represented by the scientists on board. Analyses in laboratories will be performed as stated in the scientific programme. Data will be exchanged and results presented to the authorities of Brazil and Germany.

In total 45 positions were sampled with a Van Veen grab, whereby mostly the sediment surface (0-1cm) of the sample was separated with regard to analyse clay mineralogy and biogeochemical compounds. Also sediments enriched in Halimeda and red algae were sampled separately.

In order to sample a large area of undisturbed surface sediment the giant box corer was used at 26 stations. With a surface area of 50 x 50 cm sediments were retrieved of up to 50 cm. Once on board, the overlying water was carefully removed from the box corer and the surface sediments were photographed and sampled. Sediment-surfaces were sampled separately for foraminifera and other microorganisms as well as for geochemical and geophysical studies. The front cover of the box corer was subsequently removed, the sediment cleaned, photographed and finally described. Samples for microbiological, geochemical, sedimentological, mineralogical, physical properties and stable isotope analyses were taken at 3 cm depth intervals. Subsamples (at 1.5 cm depth intervals) were taken for analyses of organic and inorganic carbon, nitrogen, biogenic opal, amino acids and amino sugars, carbohydrates, pyrolysis, phosphorus, metals, grain-size distribution and clay mineralogy. Additional plastic-plates (27 cm long) for X-ray radiographic structure analyses and separated cores (d = 6 cm) for geochemical investigations (X-ray fluorescence analyses) were taken. Finally, the uppermost 5 cm and the intervals 5 - 10 cm, 10 - 20 cm and 20 cm to the base of the box corer were washed through a 1 mm mesh sieve to collect the macro benthos.

Main tool for the sampling of complete undisturbed sediment surfaces and the overlying bottom water was the multicorer equipped with 4 tubes of 6 cm in diameter. The multicorer was used at 9 stations of the cruise. With exception of 3 sites (once, the multicorer did not release, twice, the samples were washed out), at all other stations cores were successful retrieved reaching penetration depths to about 20 cm. Failures by use of the multicorer at almost all stations were apparently caused by strong currents, especially bottom currents, and by mostly steep continental slopes, characterizing the entire NE-Brazilian continental margin. At each multicorer station, the cores were usually sampled in 1 cm slices for organic geochemical, micropaleontological, mineralogical and sedimentological studies, as well stained with a solution of 1 g rose bengal in 1 l ethanol for analyses of foraminifera. Additionally, overlying bottom water from all recieved cores was recovered for stable isotope measurements.

The piston corer was successfully applied once to obtain a 75 cm long core of undisturbed sediment. The use of this core equipment was neglected by the better possibilities of the gravity corer.

To recover deeper sediment sequences, a gravity corer with different pipe lengths (3 and 6 m) and a weight of 1.5 tons on top was used at 34 stations. Twenty-one cores were retrieved with recoveries between 0.30 m and 5.58 m. At thirteen stations we couldn't get any core recovery, because the core pipe was completely washed out caused by an accumulation of coarse-grained quartz- or foraminiferal sands on the seabed. Strong currents and a steep slope morphology along the entire NE-Brazilian continental margin were as well responsible for failures of core recovery. Altogether some 93 m of sediment cores were recovered with the gravity corer during VICTOR HENSEN Cruise leg 6. All sediment cores were measured and cut in 1 m long core pieces. At the University of Bremen these core meters will be opened, described and sampled following the procedures and methods which have been already applied there.

Suspended matter from 2 m water depth was collected with a CEPA continuous flow centrifuge at a flow rate of 10 l water min^{-1}. The suspended material was filtered and dried at 40°C, well prepared for further sedimentological, mineralogical and biogeochemical analyses. Only once the centrifuge was used directly off the mouth of the Jaguaribe River to determine the recent freshwater and sediment input which is being affected by the marine environment. Technical failure prevented further use of this instrument.

To obtain up-to-date information about the hydrographic situation of the NE-Brazilian coastal waters, a SEABIRD SBE 19 CTD profiler was used at 10 stations of VICTOR HENSEN Cruise leg 6. Equipped with a date storing unit, this device can be deployed without being connected to shipboard instruments. Generally, it was attached to the cable about several ten-meters (dependent of the variable water depth) above the multicorer. Sensors for pressure, conductivity, temperature and oxygen and an additional light beam transmissiometer (SEATECH, 25 cm side view) recorded water column properties. Immediately after each operation the raw data were transferred to a PC via a serial communication cable. Failures by data transferences to the PC arised. Therefore, a ME Meerestechnik CTD-profiler was used at following 18 stations. Data of pressure, conductivity, temperature and oxygen were directly transferred by an initiation cable to a PC. These data, revealing living conditions on the basis of recording water column properties, were used in relation to dredge samples at same stations.

Tab. 1: List of sampling stations during VICTOR HENSEN cruise JOPS II-6

Station No.	VH No.	Date 1995	Equip.	Bottom Contact (UTC)	Latitude	Longitude	Water Depth (m)	Core Recov. (cm)	Remarks
3101-1	189	14.3.	MIC/CTD	2:35	03°41,0'S	37°44,0'W	617	---	no bottom contact, no core recovery
3101-2	189		MIC	3:15	03°41,0'S	37°44,0'W	620	---	bottom contact, no core recovery
3102-1	190		MIC/CTD	4:35	03°40,0'S	37°43,0'W	775	---	bottom contact, no core recovery
3103-1	191		MIC/CTD	5:53	03°39,0'S	37°42,0'W	950	16	very pale brown sandy carbonate mud
3104-1	192		SL 6	9:00	03°40,0'S	37°43,0'W	767	518	
3105-1	193		SL 6	12:30	03°51,8'S	37°31,1'W	820	---	no bottom contact, no core recovery
3105-2	193		SL 6	13:20	03°51,8'S	37°31,1'W	850	---	no bottom contact, no core recovery
3106-1	195		CTD	20:45	04°05,0'S	37°35,6'W	23	---	---
3107-1	196	15.3.	CTD	1:31	03°56,8'S	37°31,1'W	80	---	---
3108-1	197		MIC/CTD	6:15	04°11,0'S	37°08,0'W	935	17	core recovery, 3/4
3108-2	197		SL 6	7:30	04°11,1'S	37°08,0'W	930	498	
3108-3	197		GKG	9:20	04°11,1'S	37°08,0'W	930	---	no bottom contact, no core recovery
3108-4	197		GKG	10:15	04°11,1'S	37°08,0'W	930	19	very pale brown carbonate mud
3109-1	198		MIC/CTD	12:41	04°19,0'S	37°12,0'W	37	x	core recovery, 4/4
3110-1	198		GKG	13:00	04°19,3'S	37°14,0'W	37	15	Halimeda carbonate sand
3110-2	198		SL 6	13:20	04°19,3'S	37°14,0'W	37	---	no core recovery
3110-3	198		KOL 3	14:00	04°19,3'S	37°14,0'W	37	---	no core recovery
3111-1	199		VG	14:55	04°20,0'S	37°20,0'W	20	x	Halimeda carbonate sand
3111-2	199		KOL 3	16:00	04°20,0'S	37°20,0'W	20	75	
3111-3	199		SL 3	16:45	04°20,0'S	37°20,0'W	20	---	no recovery, very coarse sediment, washed out
3112-1	200		SL 3	18:00	04°20,0'S	37°28,0'W	18	---	no recovery, very coarse sediment, washed out
3112-2	200		SL 3	18:10	04°20,0'S	37°28,0'W	18	250	sample from core catcher, qz. sand + red algae
3113-1	202	16.3.	CTD	1:07	03°56,5'S	37°31,0'W	220	---	---
3114-1	204		VG	6:19	04°23,5'S	37°36,0'W	13	x	
3114-2	204		SL 3	6:37	04°23,5'S	37°36,0'W	13	---	no recovery, very coarse sediment, washed out
3114-3	204		SL 3	6:49	04°23,5'S	37°36,0'W	13	---	no recovery, very coarse sediment, washed out
3114-4	204		GKG	7:19	04°23,5'S	37°36,0'W	13	15	qz. sand
3115-1	205		VG	9:20	04°15,0'S	37°36,0'W	24	x	Halimeda, Red algae carbonate sand
3115-2	205		GKG	9:40	04°15,0'S	37°36,0'W	24	15	Halimeda sand
3116-1	206		GKG	12:20	04°18,6'S	37°08,1'W	520	19	very pale brown carbonate sand
3116-2	206		MIC/CTD	13:30	04°18,6'S	37°08,1'W	515		core recovery, 4/4
3116-3	206		SL 6	14:30	04°18,6'S	37°08,1'W	520	---	no core recovery
3117-1	207		SL 6	16:30	04°17,7'S	37°05,5'W	800	528	
3117-2	207		MIC/CTD	17:30	04°17,7'S	37°05,5'W	800		
3117-3	207		GKG	18:30	04°17,7'S	37°05,5'W	800	27	
3118-1	211	17.3.	GKG	18:10	04°33,5'S	36°51,3'W	860	36	yellowish brown soft carbonate mud
3118-2	211		SL 6	19:20	04°33,5'S	36°51,3'W	860	550	
3119-1	212		MIC	20:40	04°34,05'S	36°49,07'W	500	8	core recovery, 2/4
3120-1	213		VG	21:45	04°34,6'S	36°53,3'W	66	x	Halimeda, red algae, sponges
3121-1	216	18.3.	VG	6:10	04°47,5'S	37°08,0'W	13	x	
3121-2	216		GKG	6:42	04°47,5'S	37°08,0'W	14	20	
3121-3	216		SL 3	7:05	04°47,5'S	37°08,0'W	14	180	
3122-1	217		VG	7:55	04°50,0'S	37°04,0'W	11	x	
3122-2	217		SL 3	8:06	04°50,0'S	37°04,0'W	11	---	no core recovery, very coarse, washed out
3122-3	217		GKG	8:19	04°50,0'S	37°04,0'W	11	17	coarse qz. sand
3123-1	218		VG	9:15	04°46,6'S	36°58,7'W	17	x	ligth brownish clayey sand
3123-2	218		GKG	9:25	04°46,6'S	36°58,7'W	17	17	ligth brownish clayey sand
3124-1	219		VG	10:31	04°39,4'S	36°57,0'W	15	x	light brown medium sized sand, red algae
3124-2	219		GKG	10:40	04°39,4'S	36°57,0'W	15	---	no core recovery, washed out
3124-3	219		GKG	10:50	04°39,4'S	36°57,0'W	15	---	no core recovery, washed out
3124-4	219		GKG	11:00	04°39,4'S	36°57,0'W	15	21	light brown medium sized sand, red algae

Tab. 1 continued

3125-1	220		VG	12:07	04°37,0'S	36°55,0'W	21	x	Halimeda sand, red algae
3126-1	221		GKG	12:50	04°34,7'S	36°53,4'W	65	---	no core recovery, washed out
3126-2	221		GKG	13:05	04°34,7'S	36°53,4'W	65	---	no core recovery, washed out
3127-1	222		GKG	14:10	04°34,4'S	36°51,8'W	680	50	
3127-2	222		SL 6	14:50	04°34,4'S	36°51,8'W	680	532	
3128-1	223		SL 6	16:00	04°34,0'S	36°49,6'W	510	536	
3129-1	224		SL 6	18:10	04°36,8'S	36°38,2'W	830	555	
3130-1	228	19.3.	VG	6:20	05°01,2'S	36°41,7'W	10	x	pale brown sandy silt
3130-2	228		GKG	6:30	05°01,2'S	36°41,7'W	10	22	fine sand to silt, surface light brown
3130-3	228		SL 3	6:55	05°01,2'S	36°41,7'W	10	---	no core recovery, washed out
3130-4	228		SL 3	7:05	05°01,2'S	36°41,7'W	10	---	no core recovery, washed out
3131-1	229		VG	8:05	04°54,5'S	36°40,0'W	23	x	
3131-2	229		GKG	8:12	04°54,5'S	36°40,0'W	23	40	
3131-3	229		SL 3	8:25	04°54,5'S	36°40,0'W	23	275	
3132-1	230		VG	9:03	04°52,5'S	36°39,0'W	10	x	coarse qz. sand
3133-1	231		VG	9:35	04°48,5'S	36°37,7'W	26	x	medium to coarse carbonate bearing qz. sand
3133-2	231		GKG	9:45	04°48,5'S	36°37,7'W	26	15	medium to coarse carbonate bearing qz. sand
3134-1	232		VG	10:30	04°43,0'S	36°36,0'W	30	x	Halimeda sand, red algae
3135-1	233		VG	11:00	04°43,7'S	36°36,1'W	33	x	sandy mud, Halimeda, red algae
3136-1	234		VG	12:12	04°42,1'S	36°33,3'W	65	x	
3137-1	235		GKG	13:20	04°40,0'S	36°34,7'W	565	30	
3137-2	235		SL 6	14:00	04°40,0'S	36°34,7'W	560	--	no core recovery
3138-1	236		SL 6	16:10	04°40,1'S	36°27,0'W	945	427	
3138-2	236		GKG	17:00	04°40,1'S	36°27,0'W	945	45	
GEOB 3139 skipped							GEOB No. 3139 skiped		
3140-1	244	20.3.	VG	16:29	04°52,1'S	36°22,8'W	15	x	coarse carb. sand, Halimeda, red algae, shell fra
3141-1	245		SL 6	17:55	04°44,5'S	36°19,2'W	710	507	
3142-1	249	21.3.	GKG	14:46	05°45,1´S	34°57,9´W	910	---	no bottom contact, no core recovery
3142-2	249		SL 6	16:24	05°45,1´S	34°57,9´W	910	---	no bottom contact, no core recovery
3143-1	250		SL 6	18:05	05°47,5´S	35°00,1´W	650	545	
3144-1	251		VG	18:50	05°46,0´S	35°00,5´W	70	x	coarse carb. and Qz-Sand, shell fragments
3145-1	253		VG	20:48	05°46,0´S	35°03,7´W	20	x	Halimeda, clayey carbonate sand
3146-1	254		VG	21:24	05°45,0´S	35°08,0´W	11	x	red algae, carbonate bearing Qz-sand
3147-1	255		VG	21:56	05°44,8´S	35°11,3´W	11	x	qz sand, few shell fragments
3148-1	256		VG	22:10	05°45,2´S	35°11,2´W	10	x	qz sand, few shell fragments
3149-1	257	22.3.	SL 6	8:23	05°00,0´S	34°49,5´W	820	429	
3149-2	257		GKG	9:00	05°00,0´S	34°49,5´W	820	36	yellowish brown pteropod-foraminifer mud
3150-1	258		GKG	15:05	06°36,4´S	34°39,8´W	525	40	yellow. brown pteropod foraminifer mud
3150-2	258		SL 6	15:30	06°36,4´S	34°39,8´W	525	530	
3151-1	259		SL 6	16,5	06°37,3´S	34°40,8´W	360	415	
3151-2	259		GKG	17:10	06°37,3´S	34°40,8´W	360	20	leight brown clayey pteropod foraminifer mud
3152-1	260		VG	18:20	06°42,0'S	34°39,5'W	250	x	yellow. brown carbonate sand
3153-1	261		VG	19:07	06°39,7'S	34°43,3'W	80	x	yellow. brown carbonate sand
3154-1	263		VG	23:10	06°18,8'S	34°55,5'W	20	x	Halimeda sand, red algae
3155-1	264	23.3.	VG	8:03	06°41,3'S	34°55,'W	10	x	yellow. brown coarse to very coarse qz. sand
3156-1	---		VG	8:30	06°45,2'S	34°54,4'W	10	x	yellow. brown coarse qz. sand, red algae
3157-1	265		VG	8:39	06°45,2'S	34°54,5'W	10	x	yellow. brown clayey carbonate -qz. sand
3157-2	265		GKG	9:45	06°45,2'S	34°54,5'W	10	x	yellow. brown clayey carbonate -qz. sand
3158-1	266		VG	10:00	06°51,3'S	35°50,5'W	10	x	yellow. brown carbonate -qz. sand, red algae

Tab. 1 continued

3159-1	267		VG	10:37	06°55,5'S	34°48,5'W	11	x	yellow. brown coarse qz. sand, shell fragments
3159-2	267		GKG	10:48	06°55,5'S	34°48,5'W	11	13	yellow. brown coarse qz. sand, shell fragments
3160-1	268		VG	11:09	06°56,5'S	34°48,7'W	10	x	yellow. brown carbonate sand, red algae
3161-1	---		VG	11:25	06°57,0'S	36°42,5'W.	22	x	yellow. brown carb. sand, red algae, Halimeda
3162-1	269		VG	12:41	06°58,4'S	34°48,1'W	9	x	clayey carbonate fine sand, red algae, Halimeda
3163-1	270		VG	13:32	06°51,8'S	34°46,5'W	15	x	medium carbonate sand, red algae
3164-1	271		VG	14:00	06°51,8'S	34°43,0'W	21	x	greyish brown carb. sand, shell frag., Halimeda
3165-1	272		VG	14:33	06°51,8'S	34°39,3'W	33	x	pale brown silty carbonate fine sand, red algae
3166-1	277		VG	14:58	06°51,8'S	34°36,0'W	40	x	Halimeda sand, few red algae
3167-1	278		GKG	16:05	06°52,0'S	34°33,7'W	350	34	pale brown carbonate mud, pteropod, foram.
3167-2	278		SL 6	16:30	06°52,0'S	34°33,7'W	350	544	
3168-1	279		VG	19:08	06°57,9'S	34°32,9'W	210	x	pale brown carbonate mud, foraminifera
3168-2	279		VG	19:32	06°57,9'S	34°32,9'W	210	x	pale brown carbonate mud, foraminifera
3169-1	282	24.3.	VG	8:21	07°08,5'S	34°46,3'W	10	x	yellow. brown carb. sand, red algae, Halimeda
3170-1	283		VG	9:00	07°08,5'S	34°41,5'W	17	x	yellow. brown carb. sand, red algae, Halimeda
3171-1	284		VG	9:41	07°08,5'S	34°36,1'W	30	x	yellow. brown carb. sand, red algae, Halimeda
3172-1	285		VG	10:20	07°08,5'S	34°31,5'W	38	x	Halimeda sand
3173-1	286		VG	10:56	07°06,8'S	34°29,6'W	48	x	Halimeda sand
3174-1	287		VG	11:35	07°06,8'S	34°28,2'W	450	x	yellow. brown clayey carbonate sand
3175-1	288		SL 6	14:40	07°03,2'S	34°27,8'W	900	398	
3176-1	289		SL 6	16:45	07°00,7'S	34°26,5'W	1385	524	washed out, no core recovery
3177-1	292	25.3.	SL 6	8:30	08°00,0'S	34°10,5'W	1130	30	yellow. brown foraminifera sand
3177-2	292		GKG	9:45	08°00,0'S	34°10,5'W	1130	37	yellow. brown foraminifera sand
3178-1	293		SL 6	11:30	07°59,5'S	34°14,5'W	1050	375	

Equipment:
- CTD - Conductivity-Temperature-Depth-Profiler
- MIC - Minicorer with 4 tubes
- SL 3 - Gravity corer (Schwerelot), 3 m
- SL 6 - Gravity corer (Schwerelot), 6 m
- VG - Van Veen grab
- GKG - Giant box corer (Großkastengreifer)
- KOL3 - Piston corer (Kolbenlot), 3 m

To collect the benthos-samples, a dredge was used 19 times. At 8 stations in a water depth of 20 m (typical red algae deposits), at further 8 stations, directly located by the shelf edge in water depths of 49 to 80 m (characteristical carbonate-rich Halimeda sands/muds with less red algae) and at additional three stations in a water depth of 200 m (carbonate-rich foraminiferal sands/muds) the dredges were used. Further employment hereof was hindered by widespread occurrences of red algae and coral limestones on the Brazilian continental shelf. Despite this, a variety of samples of marine flora and fauna was taken aboard: mussels, snails, crabs, fish, sponges, algae/seaweed and corals.

Acknowledgements

Our special thanks belong to the ZMT Bremen, and the Alfred-Wegener-Institut, Bremerhaven, whose organization and provision of the VICTOR HENSEN made this successful research project possible. Equally, we gratefully acknowledge the support and assistance of Captain Priebe, the officers and the crew of the ship, whose readiness and preparedness allowed the sampling without any problem.

Preliminary results

Late Quaternary changes on the NE-Brazilian continental margin as revealed by clay mineral and calcium carbonate fluctuations

Matthias Tintelnot (FIS)

Introduction

Terrigenous and marine sediment accumulations on the margins of the continents and on the floor of the oceans can be used as records of events which in the past have affected the continental landmasses and the regime of the oceans. When the climate changes, a subsequent change can be expected in each aspect of the earth's surface in contact with the atmosphere, including the surface of the ocean and the shoreline. Marine sediments, however, are a multichannel recorder of both biotic and mineralogic inputs into the ocean. Thus they parsimoniously record the interrelationships between pelagic and hemipelagic sedimentation processes. These processes are strongly influenced by climatically controlled factors such as changes in sea level, physical oceanographic conditions, ocean chemistry, particularly with reference to lysocline and calcium carbonate compensation depth (CCD) fluctuations, and terrigenous sediment influx. The latter is mainly dependant on climatic variations, highest during wet climates and lowest during dry climates. Changing climates additionally affect the composition and abundance of clay minerals. Weathering and erosion processes in different climatic zones may result in characteristic inorganic products. When these are carried to the oceans and deposited in offshore sediments, they convey information about the climate of adjacent continental regions, or about the oceanic and/or atmospheric circulation, at the time of deposition (McMANUS 1970; KOLLA et al. 1979).

The calcium carbonate content of deep-sea sediments has long been known to fluctuate in response to Quaternary climatical changes. SCHOTT (1935) recognized that the carbonate content of Equatorial Atlantic sediments of the last Glacial (Late Wisconsin) was lower than that of the overlying Holocene sediments. He concluded that this was caused by a relatively lower rate of carbonate deposition and a correlated relatively higher rate of clay deposition during the last Glacial. Numerous studies have confirmed that in sediments of the Equatorial Atlantic and the Caribbean carbonate contents are relatively higher in interglacial than in glacial sequences and have fluctuated in response to Quaternary climatic oscillations (e.g. BROECKER et al. 1958; HAYS & PERRUZZA 1972; DAMUTH 1975; BALSAM & McCOY 1987). More recent studies of western Equatorial Atlantic sediments by DAMUTH (1975) and BE et al. (1976) suggest that both dilution and dissolution have been important in determining the total carbonate content of the sediments. Although these studies have not resolved the relative contributions of dilution, dissolution, and productivity to the total carbonate content in Equatorial Atlantic sediments, they have demonstrated that the carbonate fluctuations are time-stratigraphic throughout the region and reflect the timing of glacial-interglacial climatic cycles.

The Late Glacial climatic change has been poorly documented along the NE-Brazilian continental margin. Only a few sedimentological and geochemical studies are available (DAMUTH 1975; KOWSMANN & COSTA 1979). However, their major concern of the correlation between the carbonate fluctuations and climatic oscillations was mainly described by undisturbed deep-sea sediments of the NE-Brazilian continental margin (below 3,500 m water depth).

This contribution of preliminary results will mainly discuss the inorganic components of marine sediments in an attempt to identify and evaluate criteria of climatic change. Additionally, the present study may provide a synoptic comparison of recent and Last Glacial sediment distributions to better explain strong climatic variables on a regional scale. How accurately the carbonate, clay mineral and grain-size distribution fluctuations reflect the nature and timing of the climatic oscillations is a major concern of the present study. Consequences of variable glacial/interglacial climates related to processes changing the land's surfaces, continental erosion rates or formations of minerals are only poorly known in NE-Brazil, and knowledge even about modern climatic conditions is uncertain (STUTE et al. 1995). Despite great efforts for many years, only few paleoenvironmental and paleoclimatic records have been presented from the tropical, subtropical and arid lowlands in Brazil (e.g. MARKGRAF 1989; LEDRU 1993; BEHLING 1995). Geomorphological studies (BIGARELLA &

ANDRADE-LIMA 1982) indicated at least two dry periods in the past: one very severe during the Pleistocene and another less intense during the Holocene. During a detailed examination of Brazilian continental margin sediments within the framework of JOPS-I (TINTELNOT 1995) and the following VICTOR HENSEN cruise JOPS-II Leg 6, long sediment cores were recovered by gravity corer on several profiles across the NE-Brazilian continental margin between Fortaleza and Recife (see Fig. 1 by ARZ et al. this volume). Here, preliminary results of core 3104-1 (Fig. 1) which was chosen for different investigations due to clear evidence that the sediment sections represent slow, uninterrupted particle-by-particle deposition, will be reported. The core probably spans the last 60,000 years and accurately reflects climatic oscillations during the Holocene and the Last Glacial (Wisconsin Glacial

Area of study: geography and geology

The region surveyed during the cruise Leg 6 is sited in the northeastern coast of Brazil, from Fortaleza to Recife, between 4° to 8°S and 34° to 39°W. The basic physiographic constitution of the Brazilian continental margin, with a well developed shelf, slope and rise, is determined as of Atlantic type, as passive margin. The area is characterized by high variability in shelf width which ranges from almost 100 km off Fortaleza to about 15-30 km between Natál and Recife. This reduced width seems to be related to low continental erosion rates and the narrow marine sedimentation zone (SUMMERHAYES et al. 1976). the shallow depth is attributed, by some authors, to inefficient marine erosion processes during the Pleistocene, and to recent uplift (MABESOONE 1994). The continental shelf is mostly shallower than 40m while its edge is about 60-70m deep.

The shelf area has a rather flat surface regulated by erosion and deposition processes. The relief features of the shelf have for the greater part been shaped through reworking of the mobil components of its sedimentary cover. Existing sand banks transversal or oblique to the coastline have been interpreted as consequences of this coastline retreat together with the action of the ocean during the Holocene transgression. Narrow channels, described in the entire study area, may represent a Pleistocene drainage system. In addition, the upper slope is steep and narrow. This E-NE region, the Ceará and Rio Grande do Norte continental slope, has a more accentuated slope (e.g. PONTE & ASMUS 1978), possibly due to faulting (especially in the vicinity of the Jaguaribe (Potiguar Basin) area; e.g. MAIA 1993) and volcanic activity along the Fernando de Noronha Ridge and not compensated by sedimentation. The shelf edge and the continental slope have been cut through by canyons and channels, remainders of the drainage during periods of regressional times. The lack of connection between the canyons and the present drainage systems suggest that many erosional features have been buried under a sediment cover deposited in them during the Pleistocene regression periods.

Maps about the distribution of surface sediments along the NE-Brazilian continental margin were published by MABESOONE & COUTINHO 1970, MABESOONE et al. 1972a, KOWSMANN & COSTA 1979, MARTINS & COUTINHO 1981 and MARTINS & WILLWOCK 1987. A comprehensive study about the "Upper continental margin sedimentation off Brazil" has been given by MILLIMAN & SUMMERHAYES (1975). More recent and detailed descriptions of surface sediments from this region are found by

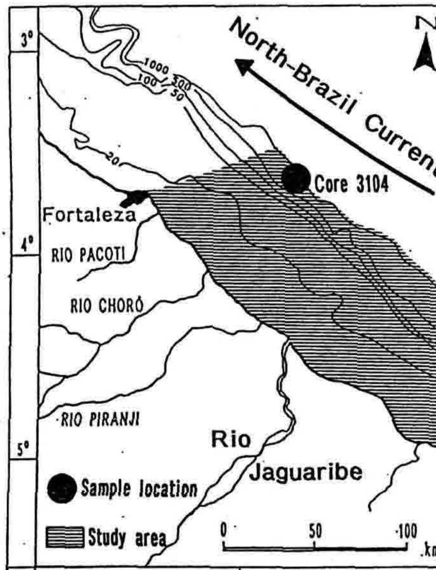

Fig. 1: Location of core 3104-1 off NE-Brazil.

TINTELNOT (1995), TINTELNOT & IRION (1996) and TINTELNOT et al. (1996). The surface of the Brazilian shelf underwent phases of submersion and exposure during the Quaternary, affected by eustatic sea-level fluctuations. About 15,000 y. B.P., at the end of the Pleistocene glaciations, a rapid sea-level rise caused submergence of the widespread coastal plains. Available data suggest that the Holocene transgression stabilized about 7,000 y. B.P. and the sea level has remained at its present position with only few oscillations (5 m; e.g. MARTIN et al. 1987; IRION et al. 1989). Since the sea level reached its present position, most fluvial sediments have remained trapped in coastal and inner shelf areas as most river-borne sediments escape to the deep sea during lower stands of sea level, when most continental shelves were subaerially exposed. Further, most shelf sediments on the Brazilian margin were deposited during the last low sea-level stages. Modern sediments are accumulating only in estuaries, in certain nearshore areas on the continental shelf, and partly on the continental slope. Because of the general lack of recent terrigenous sediment supply to the shelf, nearly all other areas are covered by calcareous algae and different kind of biogenic detritus. The carbonate sediments are usually dominated by Halimeda and branching corallines, of which most of them on the outer shelf appear to be relict, while those on the middle shelf are modern. This shelf is one of the few areas in the world, where an open, stable shelf is almost completely covered with biogenic carbonate sediments (SUMMERHAYES et al. 1975).

This northeastern part of the Brazilian coastline is also characterized by the presence of coarse-grained, quartz-rich clastic sediments, the Barreiras Formation of Tertiary age (BIGARELLA & ANDRADE 1964; MABESOONE et al. 1972b), which constitute a flat and low altitude surface. This surface reaches the coast where it has been reworked since Early or Middle Pleistocene time. For the greater part, these younger sediments overlie an eroded surface of Precambrian crystalline rocks, but in some places they are situated on Cretaceous sediments. A summary of the geological history about the NE part of the Brazilian coastline is given by MABESOONE (1994).

Methods and materials

During VICTOR HENSEN cruise JOPS-II Leg 6, surface and surface-near samples were taken by means of Van Veen grab (VG), giant box corer (GKG) and multicorer (MUC), and long sediment cores were recovered by piston corer (KOL) and gravity corer (SL 3 and 6m; PÄTZOLD et al. 1996). Especially core 3104-1, 513 cm of length, has been investigated in detail. Subsequent high-resolution gray value and sediment color scanning provided a detailed description of the main sediment facies variations in the retrieved cores (see ARZ & PÄTZOLD this volume). Additionally, chlorine and elements of higher atomic numbers were determined by a X-ray fluorescence (XRF) corescanner (NIOZ Texel; JANSEN et al. 1992). The corescanner provides a comprehensive impression of the chemical composition of the solid phase and is able to conduct rapid measurements at small intervals of 5 cm. These intervals were further exposed to coring and sedimentological, mineralogical and geochemical subsampling, thus preventing the loss of detailed information. The results are only qualitative. Therefore we verified the data with atomic absorption analyses (X-ray spectrometry and AAS) to obtain semi-quantitative data for the most important chemical elements (Ca, Fe, Sr, Ti). Further a sequential spectrometer was used which scans the complete spectra and combination of elements. Additionally, carbonate contents of the < 2 µm fraction and ground bulk samples were measured with the "Karbonat-Bombe" ELCARBO (MÜLLER & GASTNER 1971), total nitrogen and organic carbon contents were determined on ground bulk samples using a HERAEUS CHN analyser.

All sediment samples for grain-size analyses have been seperated by the "Atterberg method", which applied to the clay fraction (< 2µm) and the fine silt fractions 2-6.3µm and 6.3-20µm using the Stokes' Law relationship. For the separation of coarser silt and sand fractions (20-63µm and > 63µm) sieves were used. For clay mineral analysis, measured by standard X-ray diffraction analyses, a homogenized slurry of the < 2µm material (carbonate-free sediment fraction after 10 % HCOOH- or CH_3COOH-treatment) was smeared onto glass slides to obtain basal (001) oriented grain mounts. Patterns of 001-reflections are very useful for clay mineral identification because each spacing is related to the type of layered structure involved. Such mounting greatly reduces the possibility of size separation of clay mineral types because clay particles do not undergo settling (GIBBS 1965). Calcite (and other carbonates) was dissolved prior to the preparation because its presence in samples dedicated for clay mineral analysis is undesirable (HOLTZAPFFEL 1985). H_2O_2 treatment which is often used for removal of organic matter from the sediments was unnecessary due to generally low organic carbon concentrations. All clay fraction samples (< 2µm) were treated prior to analyse with ethylene glycol, and saturated with potassium and magnesium. Further detailed informations about identification and quantification of clay minerals are given by TINTELNOT (1995).

Results

Core 3104-1 from the upper NE-Brazilian continental slope, off the city Fortaleza (Fig. 1), penetrates Quaternary sediments approximately 60,000 years old and is largely composed of gray hemipelagic clay rich in terrigenous and organic detritus. The upper 50 cm (Holocene section; Stage 1) consist of light brown, high carbonate (> 50 %), pelagic foraminiferal ooze and marl rich in pteropods. This reflects the interruption of terrigenous sediment supply to the upper continental slope throughout the Holocene due to the last sea-level rise (e.g. DAMUTH 1975; KOWSMANN & COSTA 1979; MARTINS 1987). Deeper sequences (Stages 2 and 3) are characterized by olive to dark gray foraminifer-bearing nannofossil clay or foraminiferal and clayey nannofossil ooze. Core descriptions and lithologies are given by PÄTZOLD et al. (1996).

Grain-size distribution

The distribution of the grain sizes clay, silt and sand strongly reflects the glacial/interglacial fluctuations as well as continental and marine erosional processes in this area. Silt- and sand-rich sediments characterize the Holocene section (> 65 %). The main components of the silt-dominated Holocene sediments are carbonate fragments, foraminifers and pteropods with subordinate amounts of quartz and feldspar. The input and deposition of terrigenous sediments is neglectible, whereas down-slope transport of carbonate-rich shelf sediments takes place. The Younger Dryas cooling event is only adequately evident in the grain-size distribution of the core (Fig. 2), showing slightly higher amounts of clay (43 %) and decreasing contents of sand (14 %). Fine-grained material enriched in clay (> 70 %), formed and washed out during erosional processes of the land surfaces in the drainage basins of the rivers, is transported across the subaerially exposed shelf to the upper continental slope during the last Glacial Maximum and the following low sea-level stages. This grain-size distribution correlates exact with the calcium carbonate fluctuations investigated over the core-length. Low amounts of carbonate and coarse grain-size fractions (< 30 %) are characteristic indicators of the last Glacial Maximum and the following colder periods (and deeper sea-levels) of the Wisconsin Glacial. Low amounts of clay-size material and high contents of carbonate indicate high-stand conditions during sea-level changes associated with lacking supply of fine-grained terrestrial sediments to deeper regions of the ocean and excellent conditions of carbonate production on the shallow shelf.

Seismic investigations on the outer Amazon shelf have also shown, that the stratigraphic record contains sand layers, formed during lower sea-level conditions and most recently during transgressive conditions, with muddy regressive deposits (high-stand conditions) between them, and represents several cycles of sea-level change (FIGUEIREDO & NITTROUER 1995). They also described that sediment eroded during sea-level changes and low-stand conditions. During these periods, fine sediments from the upper portions of the subaqueous delta of the Amazon are lost (probably transported to the Amazon fan; DAMUTH & KUMAR 1975), and coarse sediments are concentrated. These erosion and transport processes also count for the distribution pattern of clay, silt and sand in this area.

Clay mineralogy

The mineral component of the fraction < 2µm of the analysed core material is mainly composed of the clay minerals smectite, illite, kaolinite and chlorite. Besides these, quartz, calcite, aragonite and feldspars are present in varying percentages.

The distribution patterns of clay minerals largely reflect interglacial/glacial climate and regional current patterns. Low smectite values (< 30 %) characterize the youngest Holocene sequence (0 to 70 cm) and the warmer periods of the last (Wisconsin) Glacial (150-240 cm, 285-355 cm and 500-513 cm; Fig. 2). Fine material enriched in smectite (> 45 %), derived mostly from the Proterozoic basement of the hinterland, is transported across the subaerially exposed shelf to the upper continental slope

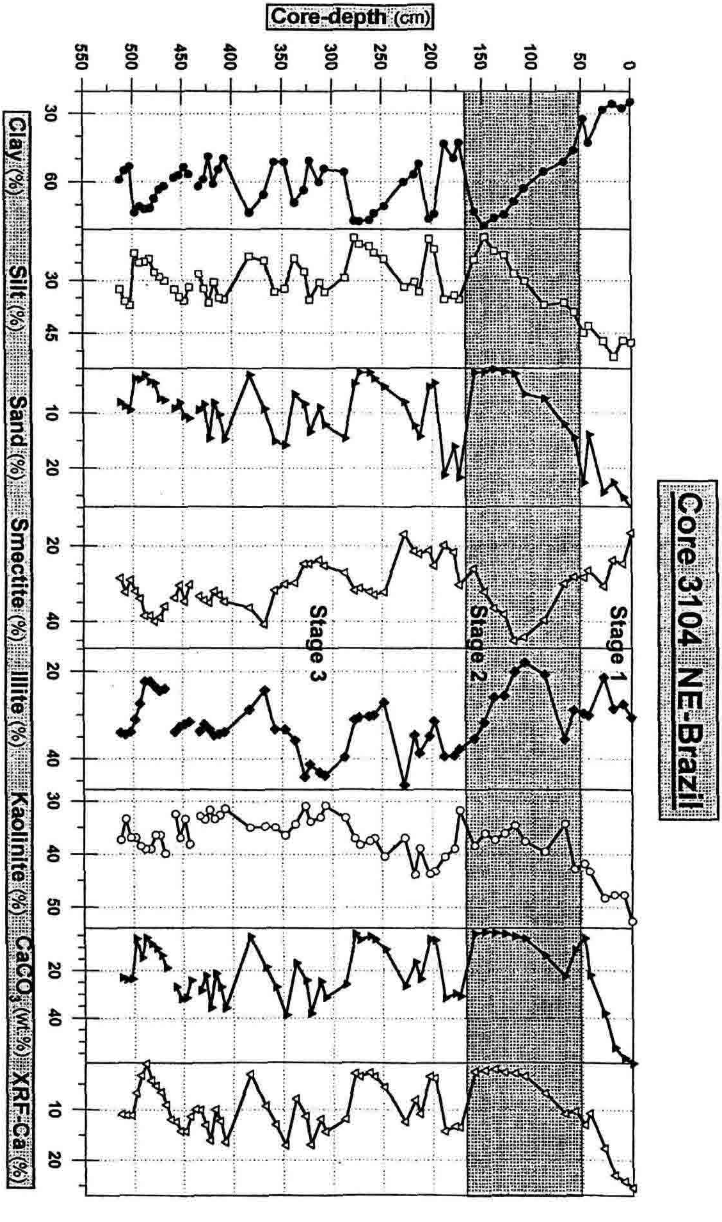

Fig. 2: Distribution pattern of the grain sizes clay, silt and sand, the clay minerals smectite, illite and kaolinite and the carbonate content over the core-length of core 3104-1.

during the Glacial Maximum and the following low sea-level stages. The highest amount of smectite was found at 100 cm core depth around 15.000 years ago (Fig. 2).

The distribution of illite shows a completely contrasting course over the core-length (Fig. 2). The Holocene section is marked by low illite contents (< 30 %). Predominantly dry climate conditions (physical weathering prevails) and strong erosion of land-surfaces in the drainage basins during longer periods of Quaternary and Tertiary times caused a deposition of these mostly illite-rich sediments (Barreiras sediments) on the shelf off NE-Brazil. Currently, shelf erosional processes can not account for the transport of these sediments over the shelf edge to the deeper ocean, and additionally, an influx of riverine illitic sediments to the shelf and upper slope is negligible and is only partly concentrated on the innermost shelf regions off the rivers Jaguaribe and Açu (TINTELNOT et al. 1994, 1996; TINTELNOT 1995). The Younger Dryas cooling event is not adequately evident in the clay mineral distribution of the core, but a following prominent illite-peak (> 35 %) may reflect a postglacial warming 12,000 to 14,000 years ago (Fig. 2). A time-shifted signal of the Glacial Maximum is characterized by lowest illite amounts (< 20 %). During the following phases of dropping and/or rising sea level at the time of the Wisconsin Glacial, increasing proportions of illite indicate the erosional activity of the North Brazil Current. Erosional processes (waves and longshore currents) reworked illite-rich sediments along a coast-parallel belt on the outer shelf. Here, dropping and rising sea levels combined with changing climatic conditions (dry to tropical) did not change the original clay-mineralogical character of this mostly Proterozoic detrital material, the illitic composition being retained all the time. Eroded sediments were transported to the upper continental slope where they have been deposited. These illite-rich sequences (> 45 %) always appear as a time-shifted signal of the maximum height (interglacial conditions) of sea-level fluctuations during the Wisconsin Glacial.

The kaolinite distribution in the core is characterized by high values in the Holocene section (> 45 %) followed by constant amounts (30-40 %) during the last Glacial Maximum and the Wisconsin Glacial (Fig. 2). Slightly higher kaolinite values correlate with carbonate minima during colder periods of the Wisconsin Glacial indicating more humid climatic conditions in the drainage basins of NE-Brazil and a higher river input of terrigenous fine-grained material across the subaerially exposed shelf to the continental slope.

The use of clay mineral assemblages to reconstruct paleoclimates has been proposed (McMANUS 1970) and indeed the global distribution of clay minerals in ocean sediments gives some support for this idea. For example, on a broad scale (making due allowance for local geological factors) chlorite has a distinct polar distribution and is clearly indicative of weathering processes at high latitudes. By contrast, kaolinite and gibbsite are primarily equatorial and tropical in distribution. Other clay minerals (e.g. illite and smectite) are less diagnostic of climate (GRIFFIN et al. 1968; RATEEV et al. 1969). Large-scale mapping of clay mineral distribution at discrete intervals in the past (e.g. KOLLA et al. 1979) could capitalize on this source of paleoclimatic data, but as yet little work along these lines has been published, especially nothing is known from the NE-Brazilian continental margin. One exception is the study of core-material off the mouth of the Amazon (DAMUTH & FAIRBRIDGE 1970). These cores contain high proportions of undecomposed feldspars in section of late Wisconsin (Würm) age and a clay mineral assemblage typical of more arid conditions (less gibbsite and kaolinite than in Holocene times). This led Damuth and Fairbridge to conclude that the Amazon Basin was considerably more arid than today, with the vast equatorial forests largely replaced by extensive grasslands, a theory which is still discussed controversily.

Calcium carbonate

Fluctuations of total calcium carbonate content in the western Equatorial Atlantic core 3104-1 (Fig. 2) are used to evaluate Quaternary climate change. They accurately reflect climatic oscillations during the Holocene and Wisconsin Glacial and correlate in detail according to earlier curves and time scales of climatic oscillations. The Holocene section (Stage 1 on Fig. 2) contains relatively high carbonate contents and the maximum value was observed at the surface of the core (59 %). Recently, the northeastern continental margin is characterized by only little to no movement of terrigenous sediments in surface or bottom river waters from the coast across the continental shelf to the upper slope. The virtual absence of terrigenous input and sedimentation along the entire narrow northeastern continental margin helps explaining the widespread growth of various calcareous algae

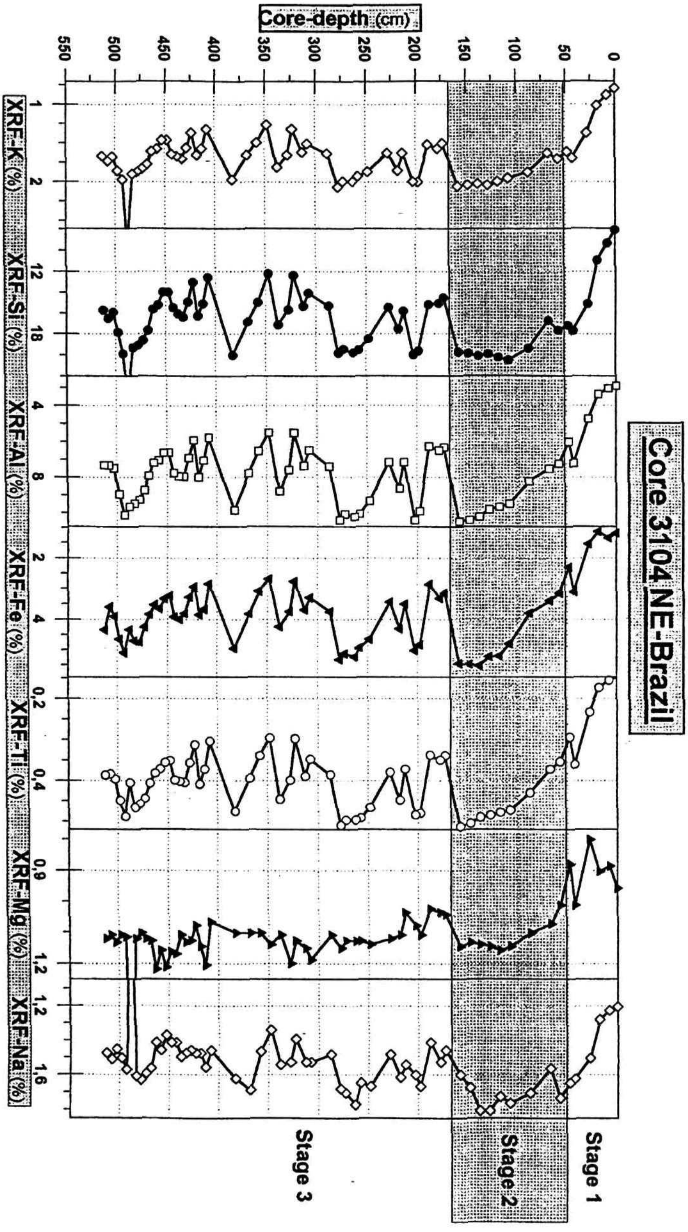

Fig. 3: Distribution pattern of the most frequent elements K, Si, Al, Fe, Ti, Mg and Na, measured by X-ray spectrometry of the bulk material over the core-length of core 3104-1. Stage 1 shows the Holocene section, Stage 2 correlates with the period around the last Glacial Maximum and Stage 3 describes the Wisconsin Glacial.

(Lithothamnium and Halimeda) and the development of the almost pure carbonate sands and results in the high carbonate amounts of Holocene sediments in the core. The Younger Dryas cooling event, which is revealed in Greenland ice and in marine and terrestrial cores in different parts of the world, is characterized by a carbonate minimum (6.2 %) probably 11,000 years ago, followed by a prominent carbonate-peak (22.6 %) which may reflect a postglacial warming 12,000 to 14,000 years ago (70 cm core-depth; Fig. 2). A broad, deep carbonate depression (< 5 % $CaCO_3$) indicates the period around the last Glacial Maximum (14,000 to 20,000 yr. B.P.) and apparently correlates with the Late Wisconsin Glacial Maximum (Stage 2 of EMILIANI 1955 and depression D1 of DAMUTH 1975). Relatively high carbonate contents characterize the Middle Wisconsin section (Stage 3 on Fig. 2) between 20,000 and 55,000 years ago, but these values are normally lower than those measured in the upper Holocene period and those observed in the last Interglacial. The core bottom is marked by a sediment layer with low carbonate contents (6 %) which apparently correlates with the Early Wisconsin Glacial Maximum.

Element composition

A large number of chemical elements were measured by X-ray fluorescence, X-ray spectometry and atomic absorption (AAS). The first set of data was collected with a X-ray fluorescence corescanner. These date were verified with X-ray spectometry and AAS analyses and are well comparable to each other. The most frequent elements K, Si, Al, Fe, Ti, Mg and Na and their down-core fluctuating concentrations are shown on Fig. 3, while Ca is plotted on Fig. 2. Fluctuations of all elements in this core reflect climatic oscillations during the Holocene and Wisconsin Glacial and therefore different erosional and transport conditions due to continental erosion, terrestrial sediment supply, sea-level fluctuations and shelf erosion. The Holocene section (Stage 1 on Fig. 3) contains very low concentrations of all elements, except of Ca and Sr, indicating the virtual absence of terrigenous input and sedimentation along the entire narrow northeastern continental margin and the widespread growth of various calcareous algae and the development of the almost pure carbonate sands on the shelf and upper slope. The last Glacial Maximum (Stage 2 on Fig. 3) is characterized by a rapid increase of all element concentrations. During this period and the following colder phases of the Wisconsin Glacial (Stage 3 on Fig. 3), terrigenous accumulation rates were high and NE-Brazilian rivers, e.g. Pacoti, Apodi and Jaguaribe, transported fine-grained, mostly smectite-rich sediments across the subaerially exposed shelf to the upper comtinental slope. Lower element concentrations during the Wisconsin Glacial therefore reflect warmer phases or periods of reducing and/or changing continental erosion and decreasing terrigenous sediment supply to the upper continental slope.

But these low amounts, especially of K, Si, Al, Fe and Ti, are still higher compared to the element concentrations of the Holocene period (Fig. 3), due to the erosion of illite-rich shelf sediments (see Chapt. 4.2) and lacking conditions of carbonate production. Nevertheless, Ca and Sr concentrations clearly increase simultaneously (Fig. 2), as has been already described above. Ca and Sr concentrations above the core-length may provide a very detailed calcium carbonate stratigraphy.

Conclusion

Fluctuations of total carbonate content, clay mineral and element composition and grain-size distribution in a western Equatorial Atlantic core of the NE-Brazilian continental slope were interpretated to evaluate Late Quaternary climate change. The core discussed in this paper was chosen for different determinations because of good evidence that the contained sediment sections represent slow, uninterrupted particle by particle deposition. The terrigenous-rich material of the core probably span the last 60,000 years and accurately reflect climatic oscillations during the Holocene and the Last Glacial (Wisconsin Glacial; Fig. 4).

Along the NE-Brazilian continental margin a Late Quaternary climate change is reflected by a distinct break in sediment accumulation rates and mineralogical composition. During the last Glacial Maximum and the following colder periods, terrigenous accumulation rates were high and NE-Brazilian rivers, e.g. Pacoti, Apodi and Jaguaribe, transported mainly smectite across the subaerially exposed shelf to the upper comtinental slope (Fig. 4). These are signals of slightly increased humidity and higher precipitation rates in the NE-Brazilian hinterland causing surficial erosion conditions in the drainage basins, and more likely tropical weathering conditions along the coastal zone. During warmer periods and upper sea-level stands, precipitation decreased and semiarid conditions predominated the river drainage basins, which caused a less sediment supply to the ocean. In these periods the clay-mineral association was dominated by illite, some chlorite and less amounts of smectite, which are products from magmatic and metamorphic outcrops in the hinterland being affected by the prevailing physical weathering conditions. Additionally, during these phases of droping and/or rising sea level in course of warmer and colder periods of the Wisconsin Glacial, increasing proportions of illite indicate the erosional activity of the North Brazil Current. This enrichment of illite originates from eroded and reworked Barreiras sediments, which have been deposited along a coast-parallel belt between the middle and outer shelf region during Tertiary and Late Quaternary times. The carbonate fluctuations correlate in detail according to earlier curves and time scales of climatic oscillations, which have been deduced previously by radiometrically-dated sea-level maxima, solar insolation fluctuations, and ice-margin fluctuations (Fig. 4).

To conclude, clay mineral assemblages, grain-size and calcium carbonate distributions and elemental composition clearly demonstrate climatic variations and therefore different erosional and transport conditions due to continental erosion, terrestrial sediment supply, sea-level fluctuations and shelf erosion.

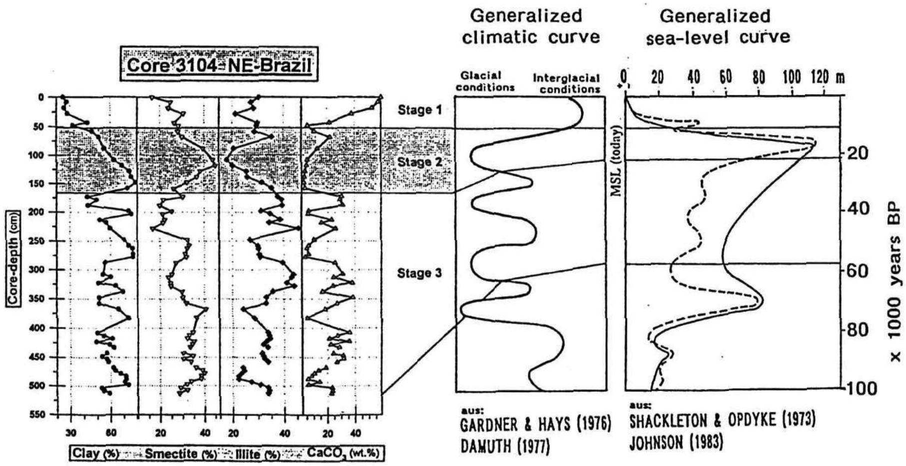

Fig. 4: A comparison between data (distribution of clay, smectite, illite and calcium carbonate) of core 3104-1 off NE-Brazil and a generalized climatic curve (data from GARDNER & HAYS 1976 and DAMUTH 1977) and a generalized sea-level curve (data from SHACKLETON & OPDYKE 1973 and JOHNSON 1983).

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Leg 7: Geophysical investigations of surface sediment structures in the Abrolhos region

Chief scientists: Dr. Fr. Theilen (IfGK), Prof. Dr. A. Figueiredo (UFF)

Cruise report

Near surface sedimentary features of the Abrolhos Bank

General objectives

The main goal of the geological-geophysical research programme in the Abrolhos region was the sedimentation history with respect to geological time and regional distribution. This should include also sea level changes to be deduced from the seismostratigraphic situation below the shelf. The second objective was the establishment of a relationship between seismic reflection characteristics, especially reflection coefficients, and sediment types derived from core stations. Leg 7 was planned for the application of reflection seismic methods including the side-scan sonar for morphological view of the sea floor structures. This was also planned to be a reconnaicance survey for the geological investigations to be executed on leg 8.

The cruise

The cruise was scheduled from March 27th to April 8th, 1995. Due to necessary repairs on the instrumentation RV "VICTOR HENSEN" left Recife on March 28th, 10.00 a.m. heading for the area under investigation on the Abrolhos Bank. The sidescan sonar was sent back to UFF in Niteroi a day before as there was no chance for a repair on board ship. The sparker and boomer system were tested underway where they showed to work properly.

The measurements started on thursday, March 30 at 10.00 p.m. in the northern part of the area under investigation with a 4000 Joules sparker, but they had to be interrupted due to the fact, that the fuses on the main power line of the ship blew repeatedly. This occured also when the low energy boomer source was used. There was obviously a defect in the power supply or the triggered capacitor bank of the EG&G system. It took the whole day to inspect the most important components of the system visually and electrically. The parts had partially to be disassembled and reassembled after being checked. This was time consuming as it had to be done very carefully with respect to the high voltage of 4 kV to be used within the system. On the afternoon of April 1st, the boomer seemed to operate satisfactorily and another streamer was deployed. After about 30 minutes it turned out, however, that the fuses blew as before, so that the measurements had to be stopped again. On sunday, April 2nd, all main parts, with the exception of the main transformer, were replaced by spares from the spare part stock available on board. The result, however, was that even 50 Ampere fuses, the highest in the main power line, still blew. It was not possible for safety reasons to bypass these fuses and to connect the power supply of the sparker system directly to the generator. This might have damaged the generator due to the uncontrolled high pulse currents. A fax sent directly to EG&G in USA requesting advice for further treatment remained without any answer. Finally the efforts to repare the EG&G-System had to be given up due to the fact that the in- struments could hardly be checked under operational conditions as the fuses blew immediately after the system was switched on. Also the number of available fuses was limited at the end of the experiments.

As the morphological situation on the Abrolhos Bank is not well known, it made sense to continue the investigations using the hull-mounted 18 kHz Echosounder of FS "VICTOR HENSEN" for further profiling in order to get information on the distribution of soft sediments and locations where cores could be retrieved within the leg 8 programme. In

Tab.1: List of sampling stations

Stat.	Latitude	Longitude	Depth	Remarks
S 01	18 27'S	38 26' W	47 m	carbonatic sediments with shells, corals fragments, fine, medium
S 02	18 28' S	39 01' W	42 m	carb. mud, biodetritus (algae, molusc.)
S 02 A	18 03' S	39 07' W	20 m	carbonatic mud, biodetritus fragments
S 03	18 27' S	39 28' W	20 m	terr. sand, carb. sand, part. biodetr.
S 04	18 43' S	39 14' W	37 m	sand, part. biodetr.
S 05	18 43' S	38 52' W	62 m	carb. mud, radiolite
S 06	18 44' S	38 30' W	62 m	carb. mud with shell fragments
S 07	18 44' S	38 23' W	54 m	carbonatic rhodoliths with brown algae, 8-12 cm diameter
S 08	18 43' S	38 12' W	30 m	carbonatic rhodoliths with brown algae, 8-12 cm diameter
S 09	19 00' S	38 19' W	33 m	rhodoliths, molusc. carb. algae (part. living)
S 10	19 00' S	38 27' W	90 m	carbonatic mud with shell fragments
S 11	19 00' S	38 40' W	34 m	rhodoliths, coarse shell fragments
S 12	18 59' S	38 59' W	53 m	carbonatic sand, fine/medium
S 13	19 20' S	39 27' W	24 m	yellow coarse sand, part. shell fragm.
S 14	19 18' S	39 45' W	60 m	rhodoliths (flat)
S 15	19 17' S	38 27' W	69 m	carbonatic mud with carb. fragments, 2-10 cm
S 16	19 37' S	39 17' W	84 m	coarse sand, carb. mud, yellow, part. with algae and shell fragments
S 17	19 42' S	39 31' W	57 m	fine sand, brown, part. biodetr.
S 18	19 38' S	39 38' W	36 m	brown sand, mud
S 19	19 35' S	39 44' W	11 m	brown sand, mud
S 20	19 41' S	39 45' W	12 m	brown mud
S 21	19 43' S	39 54' W	17 m	brown sand, medium
S 22	19 50' S	39 51' W	34 m	fine sand, fine

addition many other morphologic features and their distribution can be deduced from the echosounder records. For this reason a survey grid was established mainly in the shallow water area (Figs.1 and 2). The cha-racteristics of the sea floor were listed by the observer with respect to position and recording time. The positions from the GPS-Navigation system were stored together with date and time, true North, magnetic North as well as speed in knots and kilometers in a laptop computer every minute. The bathymetric survey allowed to map bottom morphology and bottom response of the echosounder. Bathymetric data were collected on a survey grid with parallel lines and crossing lines in a total of 1071 nautical miles (Fig. 2). The investigations were mainly focussed on the Abrolhos Bank.

Based on the distributions of bottom reflection patterns, 23 bottom sample stations were cored with a Van-Veen grab sampler. The positions and types of samples are listed in Tab. 1.

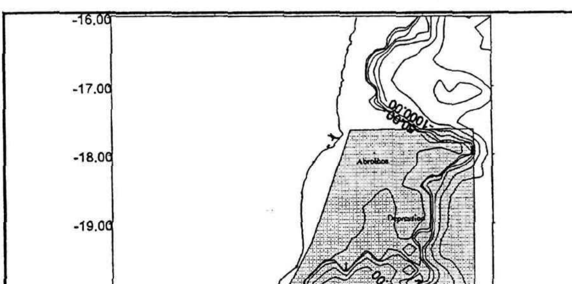


Fig.1: Area under investigation for leg 7 on the Abrolhos Bank

Results

The Abrolhos region is characterized by a shelf platform with a width of 120 nautical miles while nearby areas towards the north and south are only 30 to 40 miles wide. On the southern part of the Abrolhos Bank the 50 m isobath delineates a depression, which is 60 miles long and 30 miles wide (Fig. 1). The depth varies about 30-40 m on the eastern and northern side, but increases to the erosional depression with a maximum depth of about 90 m.

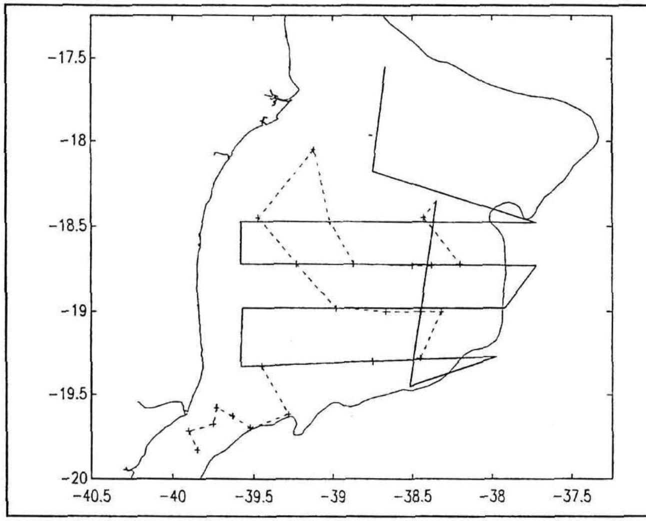


Fig 2: Survey area with location of profile numbers, including position of sample stations

The Abrolhos Bank is a rather flat platform with steep margins beyond the 200 m depth contour line. It was covered with a grid of echosounder profiles as shown in Fig. 2. The objective of these measurements was to get an assessment to small scaled morphological features of the sea floor such as roughness, ripples, depression or erosional structures. They contain information on sediment type and transport as well as on suitable locations for geological stations. Furthermore the data are used for the improvement of the bathymetric maps from that area. Fig. 2 shows also the position of geological stations where sediment samples were taken.

The improved bathymetric contour chart in Fig. 3 is derived from the data, which have been interpolated between the tracklines. It is in good correspondence with the hydrographic chart, however, the resolution is considerably higher.

Fig.3: Contour plot of the bathymetry derived from measured depths

The southern part of the bank is characterized by an embayment like depression opening to the southern shelf edge with an elevation in the center, which is accompanied on the western and eastern side by two north-south trending grabenlike structures. These are obviously of erosional origin, however, their position may have been influenced by tectonic processes in the deeper subsurface as it can often be observed below canyons on shelf edges. These troughs have obviously served as preferred drainage paths during the last sea level lowstand onto the continental slope.

The echosounder signals were characterized by different signatures either due to signal strength and length or to sea bed forms. For this reason they were classified using 6 different types. They are shown in Fig. 4.

Type A1: Smooth flat surface, various signal lengths

Type A2: Smooth wavy surface

Type B1: Rough surface with blocks

Type B2: Very rough surface

Type C: Channel within flat surface

Type D: Smooth surface with high signal lengths

Reflector type A1 is rather smooth and represents normally relative hard surfaces which become weaker with increasing signal lengths. Type A2 is similar to A1 but is characterized by a wavy form indicating sediment transport by near bottom currents.

Types B1 and B2 are characterized by a rough topography with elevations of up to 25 m above the surrounding sea floor. They are situated preferably on the central part of the shelf platform, where the sedimentation is low or even not existent. Compared to similar situations on the northern part of the Amazon Shelf and the shelf area off Rio de Janeiro, which have been investigated during the JOPS-I project, these features can be interpreted as carbonatic structures. They are obviously relicts of strong erosional phases possibly during the last sea level lowstand and may have served as a delivery area for the mass of carbonatic sediments which has been found on the outer part of the Abrolhos Bank.

Reflector type C shows a grabenlike depression with a relative depth of 30 m, which is partly refilled with sediments. The record does not allow to decide whether this is only an erosional structure such as a canyon or a depression which is also influenced by tectonic processes in the subsurface such as have been observed in the Amazon Shelf area.

Reflection type D represents a smooth surface similar to type A1, the signal length, however, is considerably longer. This type is preferably found in areas covered with carbonatic sediments.

The different echosounder signals show a clear distribution in the investigated area as can be seen in Fig. 5. The western side of the Abrolhos Bank, which is nearest to the coast, is dominated by echosignals of type A1 and A2. In the depression itself the acoustic reflection pattern is mainly of type B1 and B2, which means that the surface is rough. The penetration of the signal into the subsurface is low. This is an indication for a relative hard sediment material. On the eastern side of the depression in direction to the continental slope, the echosounder signal changes to type D.

The disribution of the reflection characteristics was compared with the sediment samples collected with a Van-Veen grab. The location of the geological stations is shown in Fig. 6 and are listed in Table 1. Sample stations of leg 8 from the Abrolhos region are taken into the evaluation too.

The sediment samples 3, 4, 13, 17, 18, 19, 20, 21 and 22 (circles) are situated near the coast. They are of terrigene origin and are all lying in areas which are characterized by the echosounder signal of types A1 and A2. This suggests to assume that the A-types are associated with terrigene sediments and can be used for the outline of their distribution.

Samples 1, 5, 6, 10, 11, 12, 14 and 15 are lying in areas of signal type B1 and B2. These samples are carbonatic sediments with shells and coral fragments or rhodoliths. It is obvious that these samples are from a thin sediment coverage over coral rocks.

Samples 2, 2A, 7, 8, 9 and 16 represent marine carbonatic sediments coming from an area which is characterized by an echosounder signal of type D. The composition of these probes is of carbonates and thus is similar to those collected in type B1 and B2 areas.

The locations of the sample stations is shown in Fig. 6. They cover the shallow part of the Abrolhos Bank down to a depth of 100 m. They were collected during leg 7 (circles) and 8 (crosses). The positions were determinated on the base of the echosounder records so that the morphologic situation at the stations is well known. This was the precondition for the attempt to correlate seismic characteristics and sediment types.

The results are shown in Fig. 7 for 4 profiles crossing the Abrolhos Bank in west-east direction. The inner slope between the coast and the central embayment is partly or totally characterized by reflection type A, which is followed by B in the deeper sections. The outer shelf platform is higher than the central area for different possible reasons. There may have been less erosion or even sediment accumulation due to bottom current patterns, but also the topography of the underlying basaltic basement has to be taken into consideration. Two narrow channels can clearly be recognized on profile 14-15 which form a broad valley with a depth of nearly 80 m on the southernmost profile. The reflection B type is indicating only little or no sedimentation in this area.

After this correlation the attempt was made to derive a sediment distribution chart based on the geological stations as well as on the echosounder profiles, which is shown in Fig. 7. Sediments of terrigene origin are deposited nearest to the coast. The middle part of the platform, which is mainly cha-

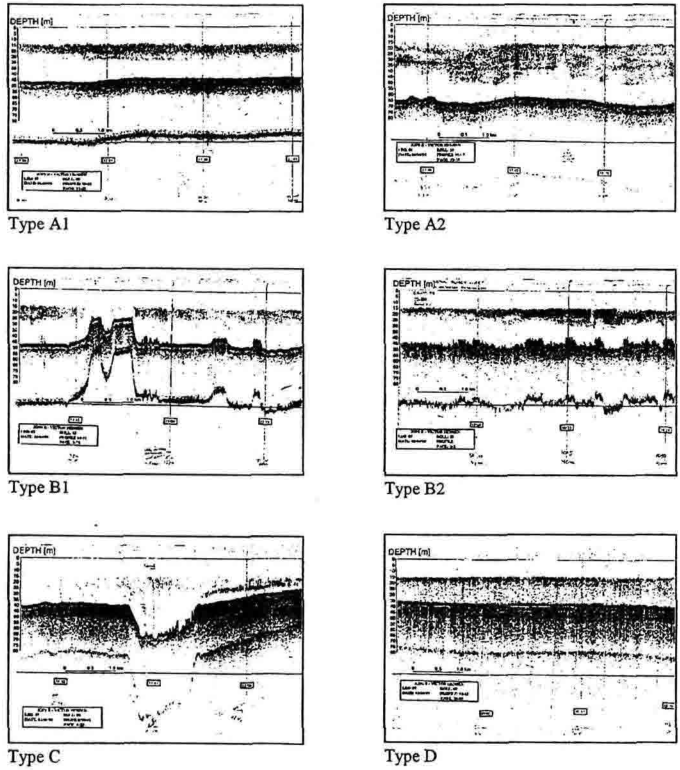


Fig.4: Characteristic sea floor reflection types

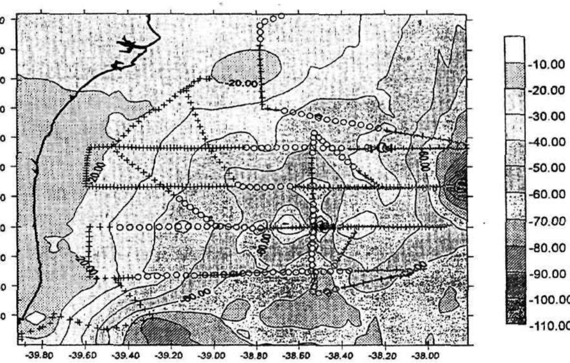
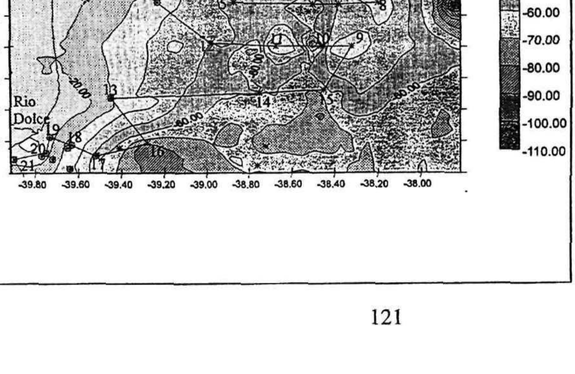


Fig. 5: Distribution of characteristic echosounder signaltypes on the Abrolhos Bank (cross: type A1 and A 2, circle: type B1 and B2, C: depressions, solid line: type D)



racterized by a rough sea floor topography, is mainly formed by coral banks with a sediment coverage of various thickness. Relicts of these banks are up to 25 m high with respect to surrounding areas. Carbonatic sands and mud are more deposited on the outer part of the Abrolhos Bank, which is partly less deep than the central part of the Abrolhos Bank.

The general situation is similar to the area north-east of the Amazon mouth. The high sediment dispersial by the Amazon river is transported during the sea level highstands along the coast to the north-west, where they are also deposited. During sea level lowstands, on the other hand, they are transported across the shelf platform to the slope forming big canyons which are preferred transport paths for the sediments. Similar to the Amazon mouth area, there is only little or even no sedimentation on the middle part of the shelf. The erosional features observed in the Abrolhos region are much more pronounced than in the Amazon mouth area. As the present day mean water depth is rather low, it can be assumed that this area was exposed to subaerial erosion for a longer time which is much stronger than erosion under submarine conditions. Former investigations led to the result that this area

Fig.6: Location of collected samples during legs 7 and 8 (Prof. C, D, E and G)

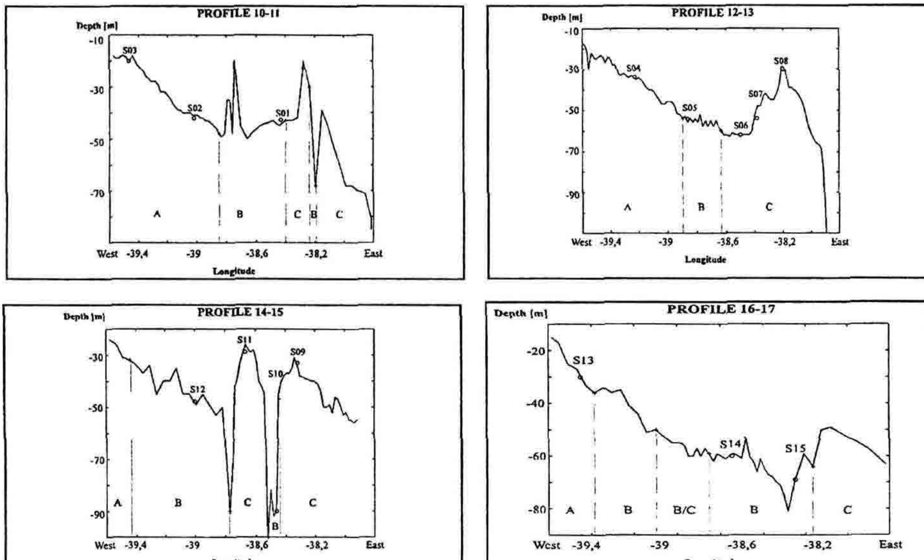


Fig. 7: Profile cross-sections divided into zones of different echo-sounder signal and position of sample stations

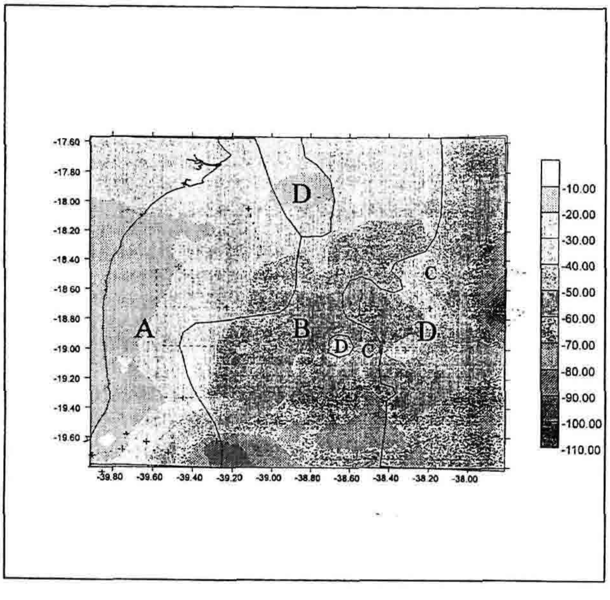


Fig. 8: Distribution of sediment types according to reflection types

was a fresh water lagoon which may have discharged through the two channels on the southern part into the ocean. In the same way, the area has been flooded from the south during the following transgressional phase of sea level changes.

Acknowledgements

We would like to thank the captain and the crew of RV "Victor Hensen" for their excellent and effective cooperation during the cruise. This project was funded by the BMBW. The project was supported by the Ministry of Science and Technology (MCT) through the agreement on science and technology between the Brazilian and German government. Funds for the ship's fuel came from the Ministry of Environment (MMA/IBAMA).

Leg 8: Paleo-oceanography and sedimentology in the Abrolhos region

Chief Scientists: Dr. J. Pätzold (GEOB), Prof. A. Figueiredo (UFF)

Cruise report

General objectives and research programme

RV VICTOR HENSEN" cruise JOPS-II, leg 8 was projected to collect sediment samples on the southeastern Brazilian continental margin and continental slope as well as to record water depths and bottom morphology. The aim is to investigate the sedimentology and paleoceanography off the coast of Vitória and in the Abrolhos Bank area. Sediment profiling with 18 kHz echosounder and geological sediment sampling were carried out on six profiles in the area between Macaé and the Abrolhos Bank (Fig. 1).

These investigations also contribute to the Sonderforschungsbereich 261 "Der Südatlantik im Spätquartär: Stoffhaushalt und Stromsysteme" ("The South Atlantic during Late Quaternary: Mass Budget and Current Systems") at Bremen University.

The cruise

After 2.5 days in port, RV VICTOR HENSEN left Vitória at 4:00 p.m. on Monday, April 10, 1995. The scientific party on board included five geologists, two biologists, and one micropaleontologist from the Universidade Federal Fluminense, Niterói, RJ, Brazil, the Universidade Federal do Paranaguá, PR, Brazil, the Universidade de São Paulo/Instituto Oceanográfico, São Paulo, Brazil, and the Geoscience Department of Bremen University, Germany. Capitão Tenente J.A. Fontainha as Brazilian observer also took part in this cruise.

VICTOR HENSEN sailed south to the first working transect off the Rio Paraiba do Sul. Sampling locations were selected after a 18 kHz bathymetric survey on a depth profile ranging from 20 to 1450 m which was carried out during the night. Profile A was sampled at four stations in water depths of 1320, 1090, 650, and 47 m using a grab sampler, a large box corer, and a gravity corer. Since sediments were soft and clayey, 6 m gravity corers were successfully recovered. Recovery of gravity corers ranged between 4.53 and 5.46 m.

The next day a second profile (Profile B) was sampled off Macaé starting on the continental slope at 1140 m and ending in 62 m water depth off Macaé. Again, selected sites were chosen after 18 kHz profiling. Six sediment stations could be covered with geological sampling devices. Three gravity cores with up to 4.82 m core recovery will allow the reconstruction of the paleoceanographic history of the Brazil Current and the underlying water masses on the southeastern corner of Brazil influenced by upwelling events. On Wednesday, April 14, continuation of sampling on this transect was hindered by rough weather conditions. One station could be added to Profile B in 700 m water depth with a Van Veen grab, but further sampling with heavy geological equipment was not possible.

VICTOR HENSEN sailed north again to continue sediment sampling on Profile A. On its way north three shallow stations with Van Veen grab samples were added off Cap São Tóme. On Thursday two sampling sites were supplemented to Profile A off Rio Paraiba do Sul including a 5.57 m gravity core in 300 m water depth. Further north two stations on the continental slope in water depths of 680 and 720 m were recovered by Van Veen grab samples. Earlier studies with under water video cameras showed ahermatypic reef development in this area in water depths between 600 and 800 m.

On Saturday, April 15, 1995, 18 kHz profiling and sampling started on Profile C off the Rio Doce. The deepest station was located at a water depth of 1290 m and sampling was continued to the mouth of Rio Doce in 22 m water depth. Two Van Veen grab stations northeast of Profile C completed sampling in this area. Due to technical failure and need of immediate repairs on VICTOR HENSEN, the scientific program of JOPS-II, leg 8 was interrupted on Saturday evening, April 15, 1995. VICTOR HENSEN spent three days in the port of Vitória before the sampling program of the cruise could be continued on Wednesday morning, April 19, 1995.

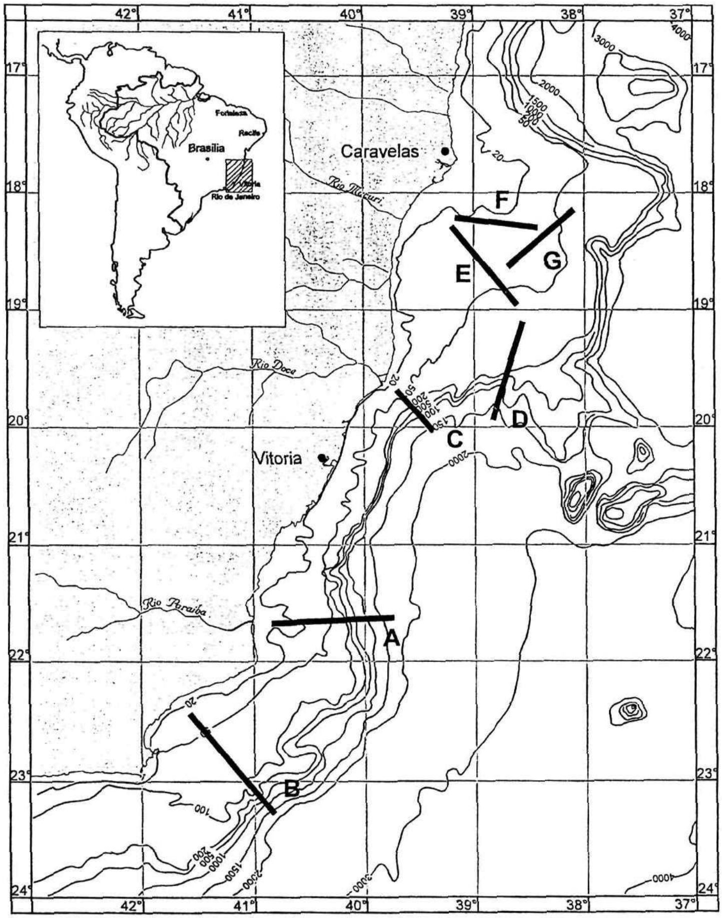


Fig. 1: Area under investigation including sample stations

The last days of the cruise concentrated on profiling and sampling the sediments of the Abrolhos Bank. In addition to 18 kHz profiling and sampling by Van Veen grab on JOPS-II, leg 7 (Figueiredo/Theilen) the sediments on Abrolhos Bank were investigated on four different profiles. Profile D started on the continetal margin at 1330 m depth and followed the central depression in a northerly direction, south of the Abrolhos Bank. The deepest part of the depression could be sampled by two gravity corers in 90 m water depth. These cores will reveal the sea level history during the last deglaciation and the Holocene. Profiles E, F, and G were located on the northwestern part of the depression, the northern and the eastern part of Abrolhos Bank. Coarse carbonate deposits prevented the use of the gravity corer in these areas of the Abrolhos Bank.

On Saturday, April 22, the sampling program of JOPS-II, leg 8 was completed with the successful recovery of a 5.24 m gravity core off Rio Doce again on Profile C in 22 m water depth. Cruise JOPS-

II, leg 8 ended on April 23, 1995 in Vitória.

Preliminary results

Geophysical and geological investigations

A list of samples and a summary description are included in Table 1. Samples were shared among the five institutions represented by the scientists on board. Analyses in laboratories will be performed as stated in the scientific program. Data will be exchanged and results presented to the authorities of Brazil and Germany. All samples collected during this cruise have a representative portion to be deposited at Banco Nacional de Amostras Geológias, PGGM/UFF.

Positioning and 18 kHz Echosounding

The positions of the GPS-navigation system were recorded, together with the date, time, true North, magnetic North, as well as speed in knots and kilometers in a laptop computer every two minutes.

An 18 kHz echosounding device installed on VICTOR HENSEN was used for recording water depth and bottom morphology. Maximum recorded water depth is 1450 m for this instrument. However, internal sediment structures could not be detected by this equipment. Thus, important information on sediment features such as thickness of sediment cover, sediment basins, correlation horizons, erosional discontinuities, slumpings or turbidites is not available.

The selection of sampling sites was based on bottom morphology, echocharacteristic and experience from earlier expeditions.

Sediment sampling

Sampling was carried out during JOPS-II, leg 8 with different geological sediment sampling devices. A box corer, a mini-corer, a gravity corer and a Van Veen grab were used. The Van Veen grab and box corer were recovered succesfully 50 and 18 times, respectively. The gravity corer, equipped with a weight of 1.5 tons and rods of 3 and 6 m length, was used 21 times. Altogether over 80 m of sediment cores were recovered at 18 stations during leg 8. Since strong currents caused problems in some areas, sediment sampling was carried out by attaching an acoustic pinger 30 m above the equipment in water depths greater than 200 m.

It was not feasible to open, describe and sample the collected sediment cores on board. Opening of the cores in the labs of the participating institutions will give further information on the quality of the samples for the scientific program of this cruise.

Tab. 1: List of sampling stations RV Victor Hensen cruise JOPS-II-8 Vitória-Vitória 10.04.-23.04.95

GEOB Station No.	VH Station No.	Date 1995	Equip.	Bottom Contact (UTC)	Latitude	Longitude	Water Depth (m)	Core recov. (cm)	Remarks
Profile A: off Rio Paraiba do Sul									
3201-1	240	11.4.	GKG	9:45	21°37,0'S	39°54,8'W	1320	---	no bottom contact, no core recovery
3201-2	240		GKG	11:15	21°37,0'S	39°54,8'W	1323	36	pale olive silty clay, bioturbated
3201-3	240		SL 6	13:15	21°37,0'S	39°54,8'W	1320	453	
3202-1	241		SL 6	14:35	21°37,0'S	39°58,7'W	1090	510	
3202-2	241		VG	15:30	21°37,0'S	39°58,7'W	1090	x	yellowish carbonate mud
3202-3	241		VG	16:30	21°37,0'S	39°58,7'W	1080	x	yellowish carbonate mud
3203-1	242		VG	17:59	21°37,0'S	40°05,7'W	647	x	
3203-2	242		SL 6	18:35	21°37,0'S	40°05,7'W	643	546	
3203-3	242		GKG	19:15	21°37,0'S	40°05,7'W	650	45	yellowish brown carb. mud, forams, pteropods
3204-1	243		VG	20:50	21°37,0'S	40°16,2'W	47	x	
3204-2	243		VG	21:35	21°37,0'S	40°16,2'W	47	x	
Profile B: off Macaé									
3205-1	245	12.4.	GKG	12:55	23°12,5'S	40°53,2'W	1140	x	overfilled, clayey carbonate mud
3205-2	245		SL 6	13:45	23°12,5'S	40°53,2'W	1135	482	
3205-3	245		MC	15:00	23°12,5'S	40°53,2'W	1115	33	
3206-1	246		SL 6	17:30	23°11,1'S	40°54,5'W	920		
3206-2	246		GKG	18:25	23°11,1'S	40°54,5'W	935	60	overfilled, clayey carbonate mud
3207-1	247		SL 6	19:53	23°09,0'S	40°57,1'W	200	400	
3207-2	247		GKG	20:10	23°09,0'S	40°57,1'W	200	20	clayey carbonate mud
3208-1	248	12.4.	VG	21:27	23°03,0'S	41°04,1'W	98	x	
3208-2	248		VG	21:40	23°03,0'S	41°04,1'W	98	x	
3209-1	249		VG	22:37	22°59,0'S	41°08,1'W	95	x	carb. sand, fragm. of molluscs, polych., bryoz.
3209-2	249		VG	22:43	22°59,0'S	41°08,1'W	95	x	carb. sand, fragm. of molluscs, polych., bryoz.
3210-1	250		VG	0:18	22°50,1'S	41°19,0'W	60	x	
3210-2	250		VG	0:30	22°50,1'S	41°19,0'W	60	x	
3211-1	251	13.4.	VG	12:21	23°10,1'S	40°55,1'W	705	x	surface disturbed, olive-gray clayey mud
3211-2	251		VG	13:00	23°10,1'S	40°55,1'W	705	---	no bottom contact, no core recovery
Off Cap Sao Tóme									
3212-1	252		VG	19:24	22°30,0'S	41°00,0'W	57	x	coarse qz. and carb. sand, rhodoliths
3212-2	252		VG	19:28	22°30,0'S	41°00,0'W	57	x	coarse qz. and carb. sand, rhodoliths
3212-3	252		VG	19:35	22°30,0'S	41°00,0'W	57	x	coarse qz. and carb. sand, rhodoliths
3213-1	253		VG	21:02	22°17,0'S	40°54,0'W	55	x	coarse carb. sand, rhodoliths, shell fragments
3213-2	253		VG	21:14	22°17,0'S	40°54,0'W	52	x	coarse carb. sand, rhodoliths, shell fragments
3214-1	254		VG	22:49	22°02,05'S	40°46,0'W	25	x	greyish silty clay with quartz sand
3214-2	254		VG	23:01	22°02,05'S	40°46,0'W	25	x	greyish silty clay with quartz sand
Profile A: off Rio Paraiba do Sul									
3215-1	255	14.4.	VG	9:03	21°37,05'S	40°11,9'W	75	x	yellowish brown medium qz. and carb. sand
3215-2	255		VG	9:12	21°37,05'S	40°11,9'W	76	x	yellowish brown medium qz. and carb. sand
3216-1	256		VG	9:51	21°37,2'S	40°08,8'W	310	x	olive gray,silty clay
3216-2	256		GKG	10:22	21°37,2'S	40°08,8'W	300	50	yellowish brown, silty clay
3216-2	256		SL 6	11:00	21°37,2'S	40°08,8'W	300	557	
Continental Slope off Rio Paraiba do Sul									
3217-1	257	14.4.	VG	12:05	21°35,2'S	40°06,4'W	675	x	yellowish brown carbonate mud
3217-2	257		VG	13:00	21°35,2'S	40°06,4'W	680	x	yellowish brown carbonate mud
3218-1	258		VG	14:55	21°25,05'S	40°10,2'W	720	x	yellowish brown silty clay
3218-2	258		VG	15:50	21°25,05'S	40°10,2'W	720	---	no bottom contact, no recovery
3218-3	258		VG	16:22	21°25,05'S	40°10,2'W	720	---	no bottom contact, no recovery
Profile C: off Rio Doce									
3219-1	260	15.4.	GKG	9:45	19°56,57'S	39°27,8'W	1285	40	yellowish brown silty mud, bioturbated
3219-2	260		SL 6	11:33	19°56,57'S	39°27,8'W	1280	426	
3220-1	261		SL 6	13:48	19°53,0'S	39°31,5'W	980	527	
3220-2	261		GKG	15:00	19°53,0'S	39°31,5'W	990	46	yellowish brown carb. mud, iron concretions
3221-1	262		GKG	16:35	19°50,6'S	39°34,8'W	510	44	yellowish brown silty carb. mud, bioturbated
3221-2	262		SL 6	17:25	19°50,6'S	39°34,8'W	510	358	
3222-1	263		VG	18:15	19°47,7'S	39°38,3'W	45	x	qz. sand
3222-2	263		VG	15:25	19°47,7'S	39°38,3'W	45	x	qz. sand
3223-1	264		SL 3	19:22	19°43,3'S	39°43,3'W	32	x	small core recovery, core washed out
3223-2	264		VG	19:28	19°43,3'S	39°43,3'W	32	x	brownish coarse to medium sand
3223-3	264		VG	19:45	19°43,3'S	39°43,3'W	32	x	brownish coarse to medium sand
3224-1	265		VG	20:17	19°41,9'S	39°46,1'W	22	---	no bottom contact, no recovery
3224-2	265		VG	20:20	19°41,9'S	39°46,1'W	22	x	brownish red clay

Tab. 1 continued

NE of Rio Doce

3225-1	266	15.4.	VG	21:35	19°38,8'S	39°38,8'W	35	x	yellowish brown clayey to sandy silt
3225-2	266		VG	21:46	19°38,8'S	39°38,8'W	35	x	yellowish brown clayey to sandy silt
3226-1	267		VG	23:20	19°38,9'S	39°24,5'W	63	x	rhodoliths (3-10 cm), partly living colonies
3226-2	267		VG	23:24	19°38,9'S	39°24,5'W	63	x	rhodoliths (3-20cm), layered and rounded shapes

Profile D: central depression, south of Abrolhos Bank

3227-1	268	19.4.	GKG	12:10	19°49,2'S	38°47,3'W	1330	48	light olive brown clay, olive gray mud pebbles
3227-2	268		SL 6	14:00	19°49,2'S	38°47,3'W	1340	564	
3228-1	269		SL 6	16:00	19°45,5'S	38°45,8'W	1095	567	
3228-2	269		GKG	17:40	19°45,5'S	38°45,8'W	1100	46	silty clay, mud pebbles,pteropods, biodetritus
3229-1	270		GKG	20:00	19°38,5'S	38°43,0'W	775	48	silty clay, mud pebbles,pteropods, biodetritus
3229-2	270		SL 6	21:10	19°38,5'S	38°43,0'W	780	514	
3230-1	273	20.4.	SL 6	9:14	18°59,9'S	38°27,8'W	90	223	
3230-2	273		GKG	9:33	18°59,9'S	38°27,8'W	90	24	light gray carbonate mud, biodetritus
3230-3	273		SL 6	9:53	18°59,9'S	38°27,8'W	90	208	
3230-4	273		GKG	10:10	18°59,9'S	38°27,8'W	90	27	light gray carbonate mud, biodetritus
3231-1	274		VG	11:40	18°46,8'S	38°31,4'W	65	x	light gray carbonate mud, biodetritus
3231-2	274		GKG	11:57	18°46,8'S	38°31,4'W	65	17	light gray carbonate mud, biodetritus
3231-3	274		SL 6	12:12	18°46,8'S	38°31,4'W	67	5	mostly washed out
3232-1	275		VG	15:54	18°28,2'S	39°01,5'W	40	x	clayey carbonate sand, biodetritus
3232-2	275		SL 6	15:59	18°28,2'S	39°01,5'W	40	561	
3232-3	275		GKG	16:13	18°28,2'S	39°01,5'W	40	22	clayey carbonate sand, bivalves, biodetritus
3232-4	275		SL 6	16:37	18°28,2'S	39°01,5'W	40	562	

Profile E: north western part of depression, south of Abrolhos Bank

3233-1	277	20.4.	VG	19:19	18°03,3'S	39°07,8'W	23	x	olive grey sandy clay
3233-2	277		SL 6	19:24	18°03,3'S	39°07,8'W	23	---	core washed out, gravel sampled in core catcher
3233-3	277		GKG	19:33	18°03,3'S	39°07,8'W	23	30	clayey carbonate sand, bryozoa
3234-1	278		VG	21:46	18°04,7'S	38°49,5'W	28	x	carbonate sand, rhodoliths, bryozoa, Halimeda
3234-2	278		VG	21:49	18°04,7'S	38°49,5'W	28	x	carbonate sand, rhodoliths, bryozoa, Halimeda

Profile G: eastern Abrolhos Bank

3235-1	283	21.9.	VG	9:15	18°00,0'S	38°12,1'W	55	x	light gray coarse carbonate sand, biodetritus
3235-2	283		GKG	9:25	18°00,0'S	38°12,1'W	35	8	rhodoliths, vessel driftet about 100m
3235-3	283		VG	9:37	18°00,0'S	38°12,1'W	55	x	rhodoliths, biodetritus, carbonate mud
3236-1	284		VG	10:46	18°07,4'S	38°21,0'W	55		not released
3236-2	284		VG	10:46	18°07,4'S	38°21,0'W	53	x	clayey carbonate sand, biodetritus, algae, corals
3236-3	284		VG	10:57	18°07,4'S	38°21,0'W	53	x	clayey carbonate sand, biodetritus, algae, corals
3237-1	285		VG	11:38	18°13,0'S	38°20,0'W	55	x	rhodoliths, carbonate mud
3238-1	286		VG	12:30	18°15,8'S	38°27,0'W	40	x	
3239-1	287		VG	13:38	18°21,5'S	38°35,7'W	50	x	carbonate sand, biodetritus, gastropods
3240-1	288		VG	14:45	18°31,5'S	38°34,0'W	55	x	carbonate sand, rhodoliths, sponges, coralls
3240-2	288		VG	14:52	18°31,5'S	38°34,0'W	55	x	carbonate sand, rhodoliths, sponges, coralls
3241-1	289		VG	16:03	18°35,0'S	38°55,3'W	50	x	carbonate sand, biodetritus, black minerals
3241-2	289		VG	16:09	18°35,0'S	38°55,3'W	50	x	carbonate sand, biodetritus, black minerals

Continuation of profile C: off Rio Doce

3242-1	290	22.4.	SL 6	16:14	19°41,9'S	39°46,1'W	22	524

Equipment:
GKG - Box corer (Großkastengreifer)
MIC - Minicorer with 4 tubes (6 cm diameter)
SL 6 - Gravity corer (Schwerelot), 6 m

Acknowledgements

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First results

Paleoceanographic reconstruction of the Brazil Current and North Brazil Current

H. W. Arz (GEOB)

Introduction

As northward and southward oriented boundary currents, the Brazil (BC) and Northbrazil (NBC) Current are of major interest for the understanding of the surface circulation of the South Atlantic. They start in the western tropical Atlantic continuing the South Equatorial Current (SEC) as weak surface currents (Fig. 1). The reduced production of North Atlantic Deep Water (NADW) during glacial periods probably caused a decrease or even collapse of the northward oriented transport of warm water masses (NBC). During this, an intensification of the Brazil Current probably occurred (Miller and Russell, 1989).

During RV Victor-Hensen cruise JOPS-II, leg 6 and leg 8, gravity cores and surface-samples from the shelf and upper continental slope of the NE-coast of Brazil were retrieved.

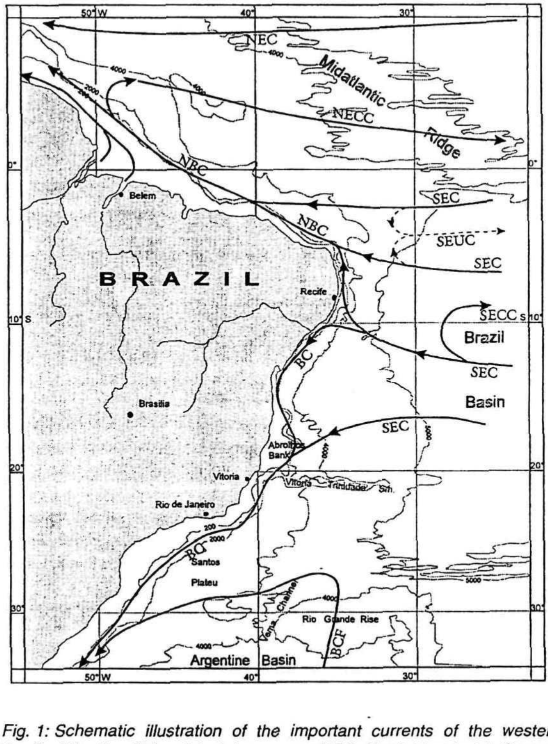


Fig. 1: Schematic illustration of the important currents of the western South Atlantic. Abbreviated terms are: NEC=Nord Equatorial Current, NECC=Nord Equatorial Counter current,, SEC=South Equatorial Current, SECC=South Equatorial Counter Current, SEUC=South Equatorial Undercurrent, NBC=Nord Brazil Current, BC=Brazil Current, BCF=Brazil Current Front (after Peterson & Stramma, 1991).

The northern study area (Fig. 2), located between Fortaleza and Recife, is characterized by a narrow, shallow shelf and a steep continental slope (Summerhayes et al., 1975; Martins & Coutinho, 1981). South of 5°S the outer shelf and upper continental slope are influenced by a weak NBC surface current (2 Sv, $1Sv=10^6$ m^3s^{-1}) which is underlayed by the strong (10 Sv, up to 80 cm/s), also north-westward flowing North Brazilian Undercurrent (NBUC). North of 5°S, more SEC-water is added to the NBC, strengthening it (Condie, 1991; Stramma, 1991; Peterson & Stramma, 1991; Schott et al., 1993; Schott et al., 1995).

A second study area between 18° and 23°S, south of the Abrolhos Banks (Fig. 3), shows comparable morphological features. As in the northern study area, recent carbonate sedimentation is dominating. During Pleistocene sea level low stands fluvial output was probably more important (especially from the Rio Doce and the Abrolhos Plateau) (de Melo et al., 1975).

Between 19° and 20.5°S the BC reaches maximum velocities of

50 to 70 m/s. A mass transport of 6.5 to max. 11 Sv were estimated for this area (Stramma, 1989, 1991; Peterson & Stramma, 1991; Signorini, 1978; Evans & Signorini, 1985).Oceanographic investigations in this area showed, that the BC follows the shelf edge with the main transport in the upper 200 m, without exceeding the 1000 m isobath. The study area is directly influenced by the southward flowing Brazil Current.

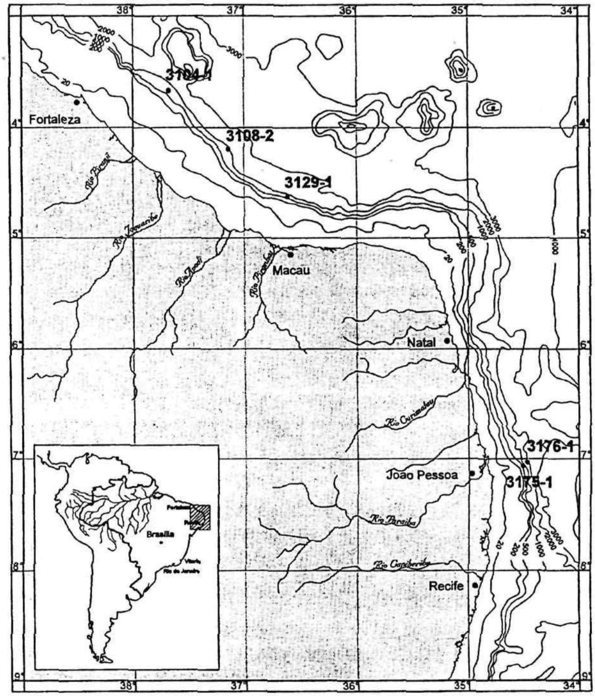


Fig. 2: Northern study area between Fortaleza and Recife; Location of gravity cores chosen for further investigations: GEOB 3104-1, GEOB 3108-2, GEOB 3129-1, GEOB 3176-1 and GEOB 3175-1.

Methods

1. Using a gravity corer, equipped with a weigth of 1.5 tons and rods of 3 and 6 meters, sediment cores of maximum 5.50 m were retrieved. On board, the sampled sediment cores were cut in one meter segments. Opening, describing and sampling the cores was carried out at GEOB (Geosience, Bremen), using GEOB internal standard methods.

2. A first important request is, to get undisturbed sediment cores to work on. The sampling area shows extreme morphological features (steep continental slope) and disturbance of the sediment can not be excluded. Detailed textural examinations to recognize slumps, turbidites etc. were carried out, using X-radiographs from one centimeter thick sediment slides (FAXITRON 43855a).

3. The core segments were cut in a work and an archive part. Covering the archive half with a special foil, profiling color scans (3 cm steps) with a Minolta Spektrophotometer type CM-2002 were made. In steps of 10 nm wavelength, the spectra of visual light (400-700 nm) was measured. Variations in the color of the sediment core and spectral composition of each measurement, allows a first characterization of the sediment. The reflection of high wavelength (red) along the core indicates fluctuations of the carbonate content (Mix et al., 1992).

4. With a XRF-scanner (CORTEX) developed at the NIOZ (Netherlands Institute for Sea Research), Texel profiling X-ray fluorescense measurements of the core segments were made. Rapid (ca. 1 min/measuring), computer-controlled measurements allow a first qualitative determination of the geochemical composition of the sediment (Jansen et al., 1992). The measured intensity of the

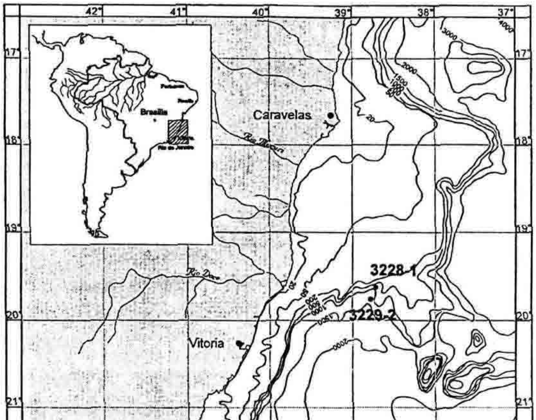


Fig. 3: Study area south of the Abrolhos Banks; Location of gravity cores chosen for further investigations: GEOB 3201-3, GEOB 3202-1, GEOB 3206-1, GEOB 3228-1 and GEOB 3229-2.

elements Ca, Sr, Fe and Ti were used for further interpretations.

5. To obtain a detailed stratigraphic record of the sediment cores stable oxygen isotops on foraminifera shells were measured. In 5 cm steps ca. 10 ml sediment were sampled from the cores. The fraction >150 mm was sieved out and dried at 55°C. Five foraminiferas (350 to 400 µm) of the species *Globigerinoides sacculifer* and *Globigerinoides ruber (pink)* (living in the upper 50 m) were picked out and prepared for massspectrometry measurements.

Preliminary results, discussion

In a first step, using core descriptions, smear slide analysis, X-radiographs and color scans, ten gravity cores from water depths between 750 and 1400 m and medium lengths of 5 m were chosen for further examiniation (Tab. 1, Fig. 2, Fig. 3). Fig. 4 shows exemplary the core description, XRF-scan, color scan and other sediment parameters of the gravity core GEOB 3104-1. The uppermost 10 to 20 cm are commonly yellowish brown colored, consisting of foraminifera rich nannofossil ooze. Along the cores, alternating dark gray to light gray sediments indicate changes in the content of carbonate (foraminifera, nannofossils) and terrigenous material. Usually the sediment is strongly bioturbated.

The XRF-measured Ca and Sr intensities show strong fluctuations of carbonate content. Compared with Fe and Ti intensities a clear negativ correlation can be observed, probably attributed to strong terrigenous dilution or reduced carbonate production during glacial periods. The comparision of Ca and Sr intensities with high wave lengths of the color scans (700 nm) correlate well (correlation coefficients r = 0,82 and 0,79). Therefore, color scans allow first assumptions of the carbonate content and may be used for core correlations. Comparing XRF-data and colorscan data from core GEOB 3104-1 with carbonate curves of stratigraphically linked sediment cores northwest of the working area (V25-56, Damuth, 1975,

Tab. 1: Location, depths, and lengths of gravity cores chosen for further investigations.

core nr.	latitude	longitude	water depth	core length
GEOB 3104-1	03°40,0' S	37°43,0' W	767 m	518 cm
GEOB 3108-2	04°11,1' S	37°08,0' W	930 m	498 cm
GEOB 3129-1	04°36,8' S	36°38,2' W	830 m	555 cm
GEOB 3175-1	07°03,2' S	34°27,8' W	900 m	399 cm
GEOB 3176-1	07°00,7' S	34°26,5' W	1385 m	524 cm
GEOB 3201-3	21°37,0' S	39°54,8' W	1320 m	453 cm
GEOB 3202-1	21°37,0' S	39°58,7' W	1090 m	495 cm
GEOB 3206-1	23°11,1' S	40°54,5' W	920 m	555 cm
GEOB 3228-1	19°45,5' S	38°45,8' W	1095 m	554 cm
GEOB 3229-2	19°38,5' S	38°43,0' W	780 m	505 cm

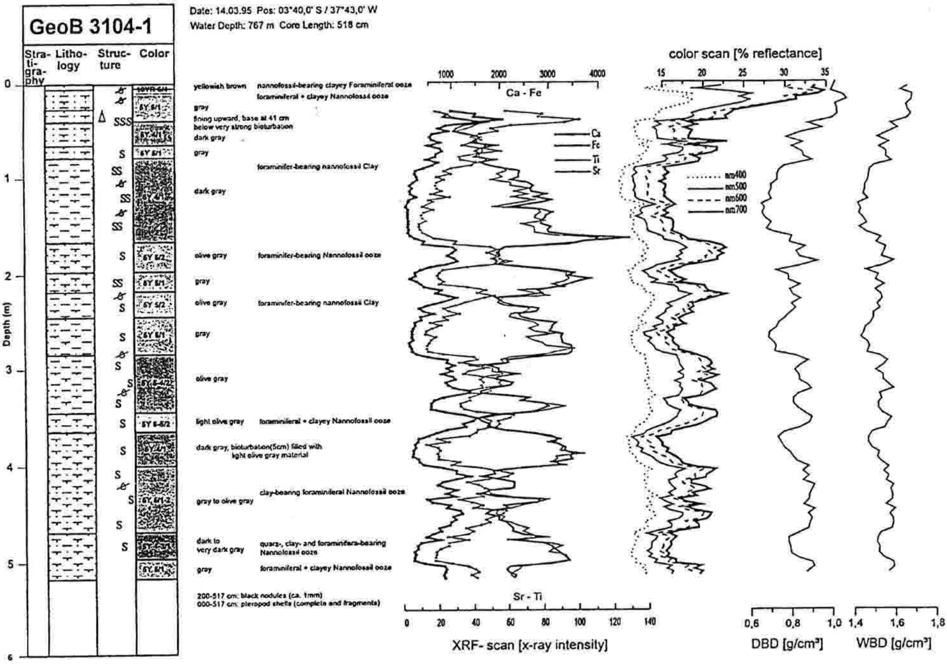


Fig. 4: Core description, XRF-data, color scan, dry and wet bulk density of core GEOB 3104-1.

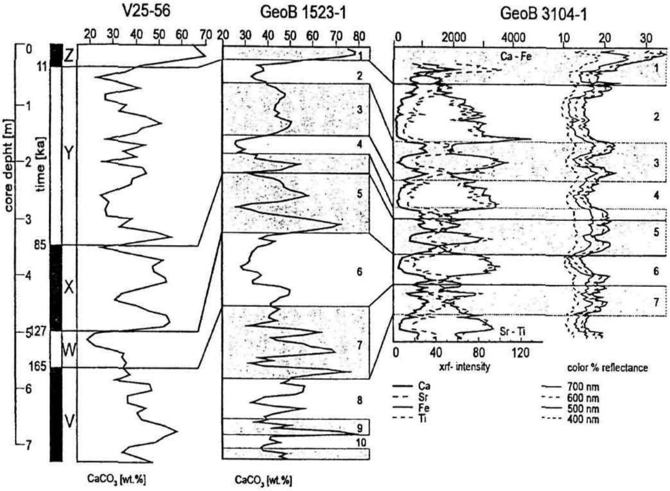
1977, and GEOB 523-1, Rühlemann, pers. comm.) a preliminary stratigraphy was developed. Therefore,core GEOB 3104-1 is approximately 250,000 years old (Fig. 5). A detailed stratigraphy based on oxygen isotope measurements still has to be worked out. With the stratigraphical information of core GEOB 3104-1 color scans were used to compare cores from the northern study area with those from the southern study area (Fig. 6). The variation of the carbonate content from southern cores are more indistinct and a correlation is very difficult. Variations in the spectral composition of individual color measurements of the sediment can be used for sediment classifications (Mix. et al., 1992). Using smear slides, the composition of the sediment was determined and then compared with the corresponding color spectra. In Fig. 7 four end members of sediment types are shown. However, the spectral composition is probably also affected by the grain size distribution of the sediment.

Outlook

The NBC and BC are western boundary currents of the South Atlantic. They are strongly linked to the wind regime of the tropical South Atlantic. Changes in circulation patterns during the late Quaternary are due to changes of the tropical wind regime (Mix et al., 1986; McIntyre et al., 1989). Hastenrath & Merle (1987) pointed out that the vertical structure of the equatorial water masses is dependent on changes of the wind regime.

Using paleotemperatures derived from isotope signals of planktic and benthic foraminifera, the vertical structure of water masses can be reconstructed. Changes of the thermocline depth in the western Equatorial Atlantic during past climatic variation could be shown (Mulitza, 1994; Kemle - von Mücke, 1994).

The behaviour of the NBC and BC during glacial-interclacial changes is not completely understood. Paleoceanographic reconstructions on sediment cores from the upper continental slope, directly in-



fluenced by the NBC and BC, allow comparisons with already existing reconstructions of the East- and Westequatorial Atlantic. Furthermore, relations to continental climate history should be possible.

Fig. 5: Stratigraphic correlation, core V25-56, GEOB 1523-1 (carbonate curve) and GEOB 3104-1 (XRF-data and color scan).

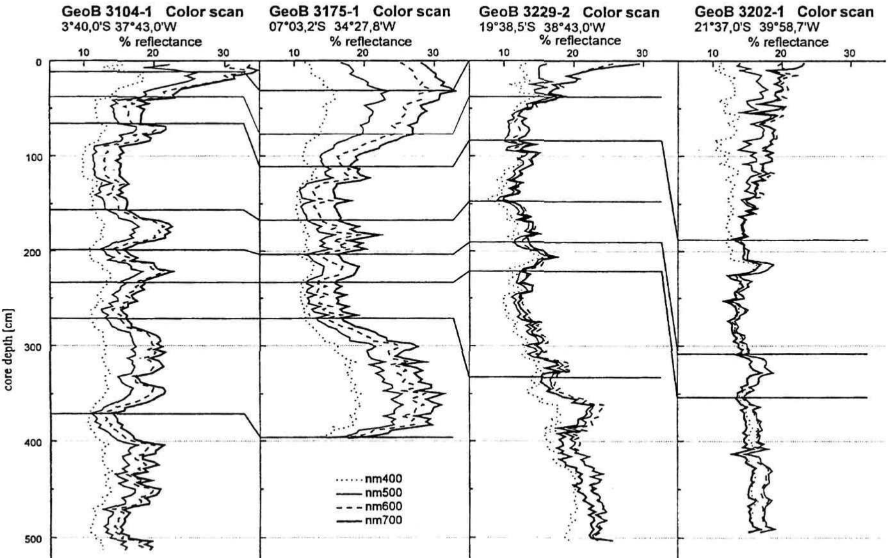


Fig. 6: Correlation of the cores GEOB 3104-1, GEOB 3175-1, GEOB 3229-2 and GEOB 3202-1, using color scans

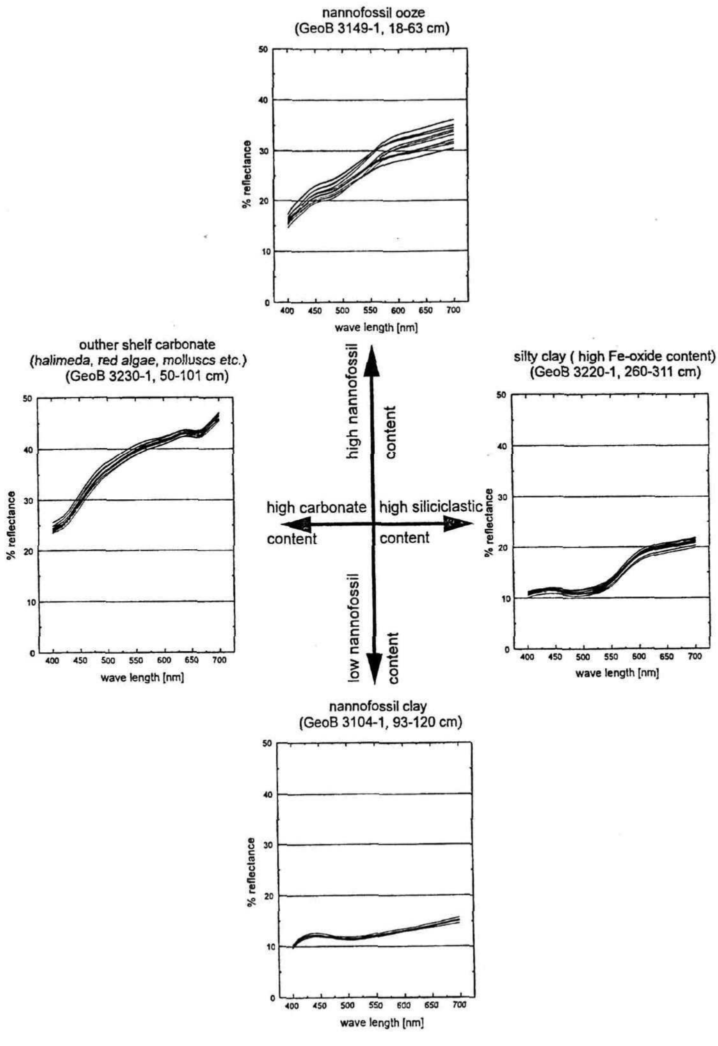


Fig. 7: Spectra of end members of color spectra related to lithology.

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Leg 9: Diversity and distribution of ichthyoplankton in the conti nental shelf waters of East Brazil

Chief scientists: Dr. W. Ekau (ZMT), Y. Matsuura (IOUSP)

Cruise report

Objectives

Flowing to southward direction, the Brazil Current encounters the physical barrier of the Abrolhos Bank at about 18°S. Consequentely the flow pattern is influenced by this shallow bank, resulting a formation of vortice, meander and upwelling movements of different water masses. The biodiversity of the demersal fish fauna is sustained by this specific oceanographic configuration, which guarantee a recruitment of larval fish in this area. It is well known that the migrating tunas also have their spawning area in the Abrolhos region.

To understand the mechanisms of recruitment and fertility of the area, the mesoscale oceanographic structure, primary production, fine scale vertical distributions of nutrients, phyto and zooplankton, and ichthyoplankton will be investigated over the entire extension of the continental shelf of the Abrolhos region.

Justification

The Abrolhos Bank is a large extension of the continental shelf (100 nm offshore), which serves as a physical barrier to the southward flow of the Brazil Current. Because of this topographical impediment, a peculiar oceanographic structure is formed in this region, such as vortices behind the sea mountains, or upwelling movement in front of them. The continental shelf of the Abrolhos region is covered by the nutrient deficient tropical waters (Brazil current) and the thermocline is formed below 150 m depth. Thus, the nutrient input in the euphotic zone is limited at some localized areas of upwelling, vortex or continental river outflow.

In spite of the oligotrophic environment, the area is characterized by the rich demersal fish fauna, which sustains a commercial fishery by hook and line.

The project proposed here has an objective to investigate the influence of this peculiar oceanographic configuration on the recruitment mechanism of the demersal and pelagic fish larvae and also to study the origem of fertility of sea, by means of studies on primary production and the distribution of pico-, nano-, and microphytoplankton. It covered the entire area between 16°S and 21°S with station interval of 30 nm, totaling 58 sampling stations.

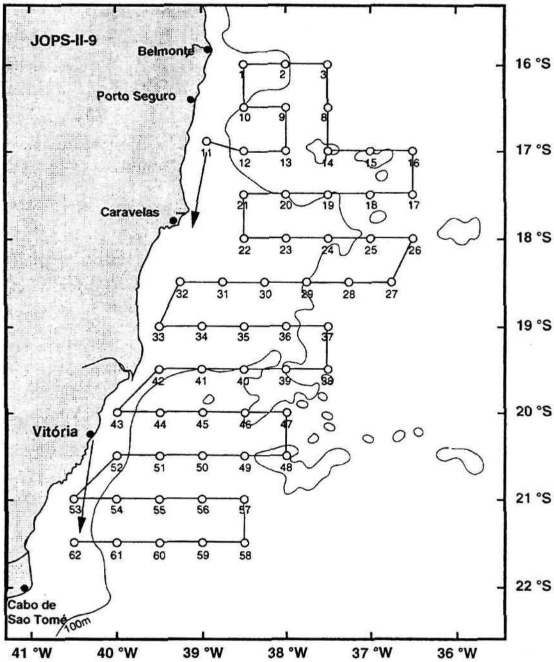
Work at sea

Itinerary

The ship left the port of Vitótia on April 25, 1995. A first station was carried out in the afternoon to test the CTD and the MULTINET and to give all participants the chance to get used to them. Regularly station work began on April 25, at about 22.00 hours with the nearcoast station of the most southern transect off Cabo de Sao Tomé.

From that time on, twelve transects perpendicular to the coast have been worked up continously during the following days. Starting point was the nearcoast station 62, then heading offshore and starting the next transect on the outermost station and heading nearshore. Every transect comprised 5 stations. Five to six stations could be worked up per day.

On each station a CTD-profile was run, and two Bongo hauls for the Zoo- and Ichthyoplankton sampling were done. Multinet was used on stations 1, 3 and 5 of each transect, if water depth was greater than 100 m. Water sampling for Microplankton, nutrients and Chlorophyll-a was carried out each second transect. Every second day on the first station with light, a sample was collected to determine



primary production. A detailed view of the work done at sea is given in the annex table.

Because of time shortage, the two outermost stations of the two northern transets were skipped. The last seven stations were worked up in a discontinous sequence.

On May 7, an additional station was done to calibrate the CTD. During the cruise, a sonde of the ZMT (ME-Ecosonde) was used to registrate the profiles. A second CTD-memory-sonde (Seabird) from IOUSP was aboard, but not used regularly. For comparison of the sondes and because the IOUSP-sonde was calibrated before the cruise in the laboratory in Sao Paulo, both sondes were lanced simultanously for 30 min. to calibrate CTD-profiles of the ZMT-sonde.

The ship finished its station work on May 6, at 18.00 hours and headed towards the port of Vitória, where the cruise leg JOPS-II-9 ended in the morning of May 8, 1995.

Fig. 1: Station plan of JOPS-II-9.

Physical Oceanography
A. Talaska (IOUSP), J. Fontainha (observer)

To describe the hydrographical situation in the investigation area, at 56 of the 58 stations CTD profiles were obtained using a ME-CTD (Stat. 35 and 62 failed). They were realized from surface to near bottom or for the top 450 m layer (limit of cable length). Data will be used to infer the distribution of various water masses and to compute the geostrophic circulation.

Marine chemistry
S. Moreira (IOUSP), M. Pompeu (IOUSP)

Water samples were collected by means of Niskin bottles in 26 stations, distributed in 6 profiles perpendicular to the coast. In the continental shelf the samples were taken at three or four depths (according to the topography) and in the oceanic region at eight depths (0, 25, 50, 75, 100, 125, 150, 250). A total of 205 samples were frozen for posterior analysis of nitrite, nitrate, amonium, phosphate and silicate at the Depart. of Biological Oceanography of the Instituto Oceanográfico da USP.

Phytoplankton
S. Moreira (IOUSP)

To the studies of Phytoplankton 40 liters of sea water were collected in two differents dephts (subsurface, euphotic layer, and deep euphótic layer). The samples were concentrated to 250 ml over Nuclepore filters (142 mm diameter) of 1m for the analysis of pico -, nano- and microphytoplankton. A total of 32 samples were collected. Quantitative measurements of phytoplankton will be done by epifluorescence microscopy and inverted microscopy and qualitative measurements will be made by electron scanning microscopy.

Chlorophyll-a and Primary production
S. Moreira (IOUSP), M. Pompeu (IOUSP)

For chlorophyll-a analysis, water samples were taken at the same depth as for nutrients. The samples were filtered, and the filters were frozen for later analysis at the Depart. of Biological Oceanography.

The primary production was studied by in situ-simulated incubation with C^{14}. The samples have been incubated on bord at different light intensities : 100, 75, 50, 25, 10 and 1 % of the surface light intensity. To characterize the light conditions in the water, the Secchi-disk has been deployed at the stations during day.

Zooplankton

Microzooplankton
M. Pompeu (IOUSP)

For the studies of microzooplankton, 20 liters of water were collected with Niskin bottles at two different depths, depending on the light intensity. The samples were concentrated to 150 ml by reversal filtration (20 µm mesh). A total of 32 samples was collected and conserved in formaldehyd solution of 1 % concentration.

Crustacean plankton
H. Rodenburg (ZMT), S. Kadler (ZMT)

For the analysis of the crustacean larvae distribution, samples were collected with Bongo and Multinet. At each station, one integrating Bongo haul was made down to 200 m or to 5m above the sea bottom. Mesh size used was 300 µm. In total 58 samples could be taken, one had to be discarded because of no propper conservation.

To analyze the vertical distribution of the plancton, a multinet with four nets was used and towed vertically in 4 depth layers: 200 to 150 m, 150 to 100 m, 100 to 50 m, and 50 m to surface. Mesh size used was 200 µm. The Multinet was used on stations deeper than 100 m. In total 23 hauls could be carried out.

The samples were conserved immediately after the catch in 4% formalin and will be analysed for species composition and abundance in the laboratory in ZMT. First rough results are expected to get until June 1996. Final results will be presented on a bilateral workshop on the results of JOPS-II in 1996 or 1997.

Fish larvae
A. Chatwin (IOUSP), W. Ekau (ZMT), S. Kadler (ZMT), Y. Matsuura (IOUSP)

For fish larvae studies, three Bongo net samples were collected at each station. A total of 58 stations could be sampled. Double oblique hauls were made from surface down to 200 m depth or to 5 m above the sea bottom at shallow stations.

For analysis of the distribution of fish larvae, a 300µm and a 500µm sample was collected. The samples were conserved immediately after the catch in 4% formalin and will be analysed for species composition and abundance in the laboratories of the Instituto Oceanografico da Universidade de Sao Paulo (300µm mesh sample) and in the Center for Tropical Marine Ecology in Bremen (500µm mesh sample). First rough results are expected to get until June 1996. Final results will be presented on a bilateral workshop on the results of JOPS-II in 1996 or 1997.

Another 500µm mesh sample was preserved in neutralized ethyyl alcohol for age studies.The samples will be analysed at the Instituto Oceanografico da Universidade de Sao Paulo.

Tab. 1: Station plan during JOPS II-9 with positions, time and gear used

Station work

Date	Time	Position	Lat.	Long	CTD	water sampling for Phyto-Micro-zoopl.	Chl.a Nutri.	Prim. Prod.	Bongo 2x	Multinet vert.
25.4.1995	14:30		20 ° 45 S	39 ° 55 W	X	Experimental station, no sampl				X
25.4.1995	22:05	62	21 ° 30 S	40 ° 30 W	X				X	
26.4.1995	01:51	61	21 ° 30 S	40 ° 00 W	X				X	
26.4.1995	06:13	60	21 ° 30 S	39 ° 30 W	X		X	X	X	X
26.4.1995	11:48	59	21 ° 30 S	39 ° 00 W	X				X	
26.4.1995	16:05	58	21 ° 30 S	38 ° 30 W	X				X	X
26.4.1995	20:43	57	21 ° 00 S	38 ° 30 W	X	X	X		X	X
27.4.1995	02:19	56	21 ° 00 S	39 ° 00 W	X		X		X	
27.4.1995	07:34	55	21 ° 00 S	39 ° 30 W	X	X	X		X	X
27.4.1995	12:49	54	21 ° 00 S	40 ° 00 W	X		X		X	
27.4.1995	17:36	53	21 ° 00 S	40 ° 30 W	X	X	X		X	
27.4.1995	22:23	52	20 ° 30 S	40 ° 00 W	X				X	X
28.4.1995	01:54	51	20 ° 30 S	39 ° 30 W	X				X	
28.4.1995	06:05	50	20 ° 30 S	39 ° 00 W	X		X	X	X	X
28.4.1995	10:55	49	20 ° 30 S	38 ° 30 W	X				X	
28.4.1995	15:18	48	20 ° 30 S	38 ° 00 W	X				X	X
28.4.1995	19:23	47	20 ° 00 S	38 ° 00 W	X	X	X		X	X
29.4.1995	00:43	46	20 ° 00 S	38 ° 30 W	X		X		X	
29.4.1995	06:00	45	20 ° 00 S	39 ° 00 W	X	X	X		X	X
29.4.1995	11:09	44	20 ° 00 S	39 ° 30 W	X		X		X	
29.4.1995	15:26	43	20 ° 00 S	40 ° 00 W	X	X	X		X	
29.4.1995	21:08	42	19 ° 30 S	39 ° 30 W	X				X	
30.4.1995	00:54	41	19 ° 30 S	39 ° 00 W	X				X	
30.4.1995	04:36	40	19 ° 30 S	38 ° 30 W	X				X	X
30.4.1995	08:15	39	19 ° 30 S	38 ° 00 W	X		X	X	X	
30.4.1995	12:16	38	19 ° 30 S	37 ° 30 W	X				X	X
30.4.1995	17:26	37	19 ° 00 S	37 ° 30 W	X	X	X		X	X
30.4.1995	22:58	36	19 ° 00 S	38 ° 00 W	X		X		X	
1.5.1995	02:39	35	19 ° 00 S	38 ° 30 W	X	X	X		X	X
1.5.1995	07:06	34	19 ° 00 S	39 ° 00 W	X		X		X	
1.5.1995	10:54	33	19 ° 00 S	39 ° 30 W	X	X	X		X	
1.5.1995	14:48	32	18 ° 30 S	39 ° 15 W	X				X	
1.5.1995	18:15	31	18 ° 30 S	38 ° 45 W	X				X	
1.5.1995	21:50	30	18 ° 30 S	38 ° 15 W	X				X	
2.5.1995	01:18	29	18 ° 30 S	37 ° 45 W	X				X	X
2.5.1995	06:16	28	18 ° 30 S	37 ° 15 W	X		X	X	X	
2.5.1995	11:06	27	18 ° 30 S	36 ° 45 W	X				X	X
2.5.1995	16:25	26	18 ° 00 S	36 ° 30 W	X	X	X		X	X
2.5.1995	21:51	25	18 ° 00 S	37 ° 00 W	X		X		X	
3.5.1995	02:32	24	18 ° 00 S	37 ° 30 W	X	X	X		X	
3.5.1995	06:53	23	18 ° 00 S	38 ° 00 W	X		X		X	
3.5.1995	10:49	22	18 ° 00 S	38 ° 30 W	X	X	X		X	
3.5.1995	15:04	21	17 ° 30 S	38 ° 30 W	X				X	
3.5.1995	18:30	20	17 ° 30 S	38 ° 00 W	X				X	
3.5.1995	22:54	19	17 ° 30 S	37 ° 30 W	X				X	X
4.5.1995	03:40	18	17 ° 30 S	37 ° 00 W	X				X	
4.5.1995	08:08	17	17 ° 30 S	36 ° 30 W	X		X	X	X	X
4.5.1995	12:57	16	17 ° 00 S	36 ° 30 W	X	X	X		X	X
4.5.1995	19:09	15	17 ° 00 S	37 ° 00 W	X		X		X	
5.5.1995	00:03	14	17 ° 00 S	37 ° 30 W	X	X	X		X	
5.5.1995	04:26	8	16 ° 30 S	37 ° 30 W	X				X	X
5.5.1995	09:47	3	16 ° 00 S	37 ° 30 W	X	X	X		X	X
5.5.1995	14:51	2	16 ° 00 S	38 ° 00 W	X		X		X	
5.5.1995	18:36	1	16 ° 00 S	38 ° 30 W	X	X	X		X	
5.5.1995	22:18	10	16 ° 30 S	38 ° 30 W	X				X	X
6.5.1995	02:52	9	16 ° 30 S	38 ° 00 W	X				X	
6.5.1995	07:45	13	17 ° 00 S	38 ° 00 W	X		X	X	X	
6.5.1995	12:14	12	17 ° 00 S	38 ° 30 W	X				X	X
6.5.1995	17:09	11	16 ° 42 S	38 ° 56 W	X				X	
7.5.1995	06:00		17 ° 57 S	38 ° 46 W	CTD-calibration					

First results

Diversity and distribution of macrozooplankton in the eastern continental shelf waters off East Brazil.

W. Ekau (ZMT), Y. Matsuura (IOUSP), S. Torbohm-Albrecht (ZMT)

General objectives

Flowing to southward direction, the Brazil Current (BC) encounters the physical barrier of the Abrolhos Bank at about 18°S. Consequently the flow pattern is influenced by this shallow bank, resulting a formation of vortex, meander and upwelling movements of different water masses. The biodiversity of the demersal fish fauna is sustained by this specific oceanographic configuration, which guarantee a recruitment of larval fish in this area. It is well known that for example the migrating tunas have their spawning area in the Abrolhos region.

To understand the mechanisms of recruitment and fertility of the area, the mesoscale oceanographic structure, primary production, fine scale vertical distributions of nutrients, phyto and zooplankton, and ichthyoplankton was investigated over the entire extension of the continental shelf of the Abrolhos region.

Hydrography

Objectives

The Abrolhos Bank is a large extension of the continental shelf (100 nm offshore), which serves as a physical barrier to the southward flow of the Brazil Current (BC). Because of this topographical impediment, a peculiar oceanographic structure is formed in this region, such as vortices behind the sea mountains, or upwelling *movement in front of them.*

The hydrographic situation was analysed to describe the abiotic environment of the plankton communities. In addition the data will serve for describing the current patterns and calculate geostrophic currents and transport of water masses in the area, and contribute to the knowledge of the large scale BC system.

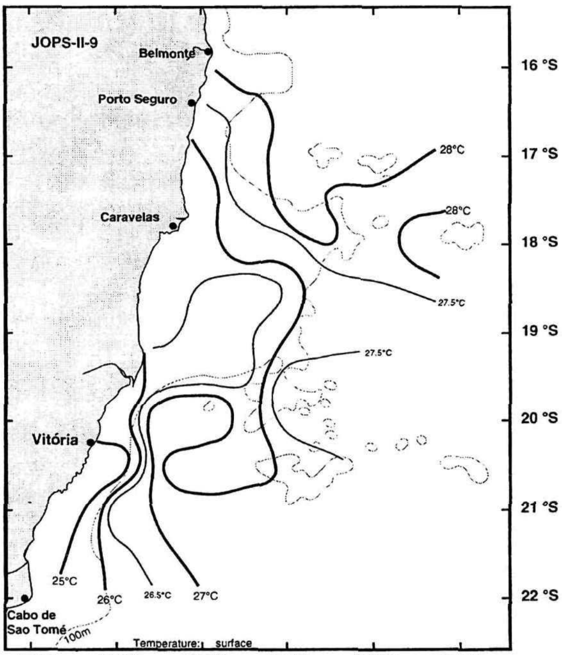


Fig. 1: Temperature in 5 m depth.

Methods

To describe the hydrographical situation in the investigation area, at 56 of the 58 stations CTD profiles were obtained using a ME-CTD (stat. 35 and 62 failed). They were realized from surface to near bottom or for the top 450 m layer (cable length). Data will be used to infer the distribution of various water masses and to compute the geostrophic circulation.

Results

The temperature distribution at the surface (5m water depth) is described in fig. 1. The area of the Abrolhos bank is influenced by the warm waters of the Brazil current (BC). Water masses with temperatures of 28 to 29°C are found in the northern area. The temperatures decrease slightly in the east and southeast down to 27.5 and 27°C. Cold water, originating from the nearshore northward flowing Malvinas current (MC), surrounds Cabo de Sao Tomé and follows the coast up to Vitória. A mixing of these water masses occurs on the broad shelf area around and south of Abrolhos Arquipelago, where water masses from the Brazil current stop those from the MC and force them to turn to the south. This results in a gyre south of the bank between 20 and 21°S, 38 and 40°W.

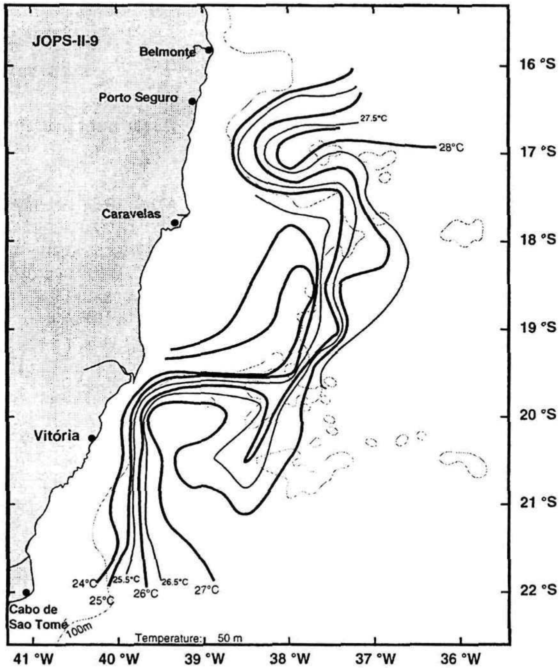


Fig. 2: Temperature in 50 m depth.

Temperature in 50 m depth shows a similar distribution (fig. 2). A difference is that the warm (>26.5°C) waters do not appear on the continental shelf with water depths beneath 100 m. It can be seen clearly, that colder water of less than 25 °C, originating from the southwesterly incoming MC-offshoot, flows over the shelf and dominates the deeper water layers. These waters occupy nearly the whole area of shelf less than 100 m deep.

Upwelling events have been observed, but they were very weak and are not visible in the preliminary charts in figs. 1 and 2. Further detailed analysis of the data will be done by a working group at the Oceanographic Institute of the Sao Paulo University.

Zooplankton

Objectives

The aim of the project was to study the zooplankton community and its relation to the hydrographical situation. From the general position and direction of the currents and watermasses it is known, that, caused by topographical barrier of the Abrolhos Trinidade ridge, a number of vortices occurs, which leads to a more complicated pattern of water masses in the investigation area. In the south, the offshoot of the MC influences the situation with colder waters.

The sampling methods and strategies had been designed to describe the pattern of the geographical distribution and the taxonomical composition of the zooplankton community. Furthermore it is the aim to relate composition and distribution pattern to water masses to get an information on secondary production in the area.

Tropical and subtropical plankton communities meet in this area. An important feature in the analysis of the data will be the location and kind of this faunal border, whether it is relatively straight and abrupt or meandering and smooth.

Vertically stratified samples were collected to describe the vertical distribution and to look for vertical migration of relevant taxa.

The results will be used to support the investigations on the importance of this area as a retention area for plankton organisms, productivity and as feeding area of fish stocks.

Methods

For the analysis of the crustacean larvae distribution, samples were collected with Bongo and multinet. At each station, one integrating Bongo haul was made down to 200 m or to 5m above the sea bottom. Mesh size used was 300 µm. In total 58 samples could be taken, one had to be discarded because of no proper conservation.

To analyse the vertical distribution of the plankton, a multinet with four nets was used and towed vertically in 4 depth layers: 200 to 150 m, 150 to 100 m, 100 to 50 m, and 50 m to surface. Mesh size used was 200 µm. The multinet was used on stations deeper than 100 m. In total 23 hauls could be carried out.

The samples were conserved immediately after the catch in 4% formalin. In the laboratory total biomass of the catches was estimated as wet weight in *mg*m^{-3}*. Taxonomic classification up to now was done to class level. Bongo and multinet samples from five stations, two from the southwest, one from the shelf plateau and two from the north, could be analysed up to now. Results are presented in the following.

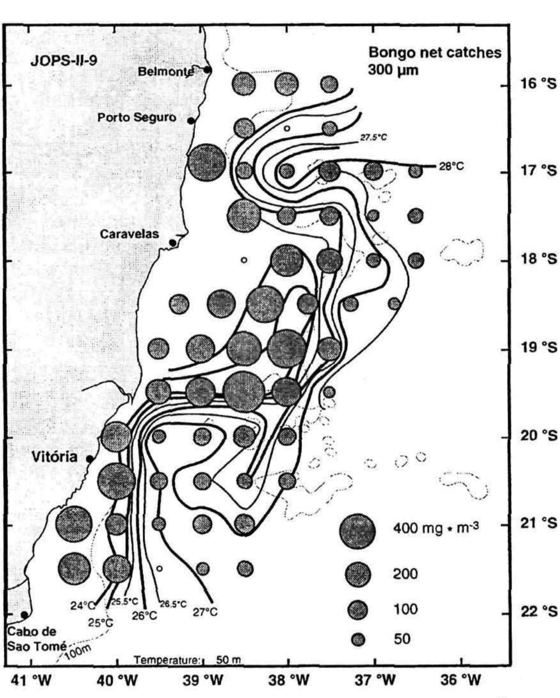


Fig. 3: Zooplankton biomass in 300 µm Bongo catches in mg*m^{-3}

Results

Total biomass in the Bongo-catches (300µm) varied between 33 and 469 *mg*m^{-3}*. Distribution of biomass follows the isotherms very clearly. High biomass values (>200 *mg*m^{-3}*) are found in areas, where temperature in 50 m water depth does not exceed 25.5°C. If water temperature is increasing, as it is found at the southeast and northeast stations, total biomass stays between 33 and 140 *mg*m^{-3}*. Highest biomass values were found in the southwest within the direct influence of the MC, and on the Abrolhos shelf plateau, specially on the outer side, where temperature is lowest (< 24°C). High biomass values in the north at stations 11 and 21 may be induced by terrigeneous input of nutrients, which come from small mangrove bordered rivers between Belmonte and Caravelas.

The following five stations had been analysed in more detail: Stations 18 and 19 from the north easterly edge of the Abrolhos plateau, station 40 from the southern edge and the most southwesterly stations 61 and 62.

Tab. 1 : Plankton composition on 5 selected stations; n per 100 m³

Station		18	19	40	61	62	Σ
water depth		3700	2900	78	1280	24	
Foraminifera		110,7	17,7	143,2	0,0	4.311,5	4.583,1
Hydrozoa		326,3	490,4	612,1	217,4	7.473,7	9.119,9
Copepoda	calanoid	5.143,0	8.795,3	9.507,2	26.589,7	87.954,7	137.989,9
	cyclopoid	528,3	478,8	362,7	3.603,3	7.933,2	12.906,3
	harpacticoid	0,0	3,6	8,4	6,8	5,4	24,2
	calligiform	9,7	18,3	34,6	178,6	20,2	261,4
	Nauplii	0,0	585,2	0,0	0,0	0,0	585,2
Copepoda	*total*	*5.681,0*	*9.881,2*	*9.912,9*	*30.378,4*	*95.913,5*	*151.767,0*
Ostracoda		419,5	336,9	124,1	434,9	452,7	1.768,1
Stomatopoda		12,6	1,1	26,2	7,3	18,9	66,1
Euphausiacea		225,3	434,4	205,2	248,5	0,0	1.113,4
Decapoda		210,0	64,8	832,8	431,7	1.994,1	3.533,4
Mysidacea		0,7	0,3	0,0	0,0	1.552,1	1.553,1
Isopoda		0,0	0,0	0,0	0,0	1,3	1,3
Amphipoda		4,4	13,3	34,6	0,0	2.000,8	2.053,1
Bryozoa		0,0	3,3	0,0	0,0	0,0	3,3
Chaetognatha		186,5	390,1	1.336,4	1.615,3	5.633,3	9.161,6
Echinodermata		0,0	39,9	0,0	0,0	237,1	277,0
Asterioridae		10,2	0,0	2,4	683,4	0,0	696,0
Thaliacea		24,3	443,3	2.635,7	605,7	2.026,4	5.735,4
Appendicularia		621,5	301,5	2.481,8	1.087,2	4.139,0	8.631,0
Pisces		40,5	71,8	223,1	152,4	105,1	592,9
Mollusca		173,6	61,0	547,7	959,8	471,6	2.213,7
Polychaeta		7,8	18,3	23,9	0,0	409,6	459,6
Cladocera		15,5	0,0	0,0	6.709,5	40.355,7	47.080,7
Total		8.070,4	12.569,3	19.142,1	43.531,5	167.096,4	

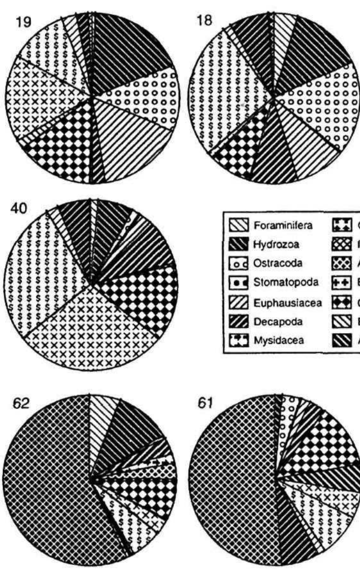
Abundance and composition of the zooplankton varied strongly at the different stations. In total 8,000 to 167,000 organisms were found per 100m³ filtered volume. The plankton was sorted into 24 major taxonomic groups (Tab.1). Highest numbers of organisms were found at station 62, a shallow shelf station, followed by the offshore station 61. Significantly the lowest total abundance occurred in the north with 8,000 and 12,600 ind./100m³ , increasing slightly at the shelf station #40 (19,000 ind./100m³).

Copepods were dominating at all five stations, abundance varied, however. Less copepods were found at the two shallow stations #40 and #62 (52.7 and 57.4%). The other stations showed percentages around 70% with a maximum at station 19 (78.6%), indicating oceanic influence from the BC water masses.

Other abundant groups were Appendiçularia, Thaliacea, Hydrozoa, Foraminifera, Decapoda, Chaetognatha and Cladocera. All these groups were highly abundant at the shallow station #62. In addition at this station large numbers of Amphipoda and Mysidacea were found, indicating the influence of the bottom and demonstrating, that the gear reached the near bottom water layer. The most important group aside the copepods were the Cladocera, which represent more than 50% of the non-copepod fauna at the southern stations. Euphausiaceae, living in offshore waters, are found only at stations #61, not at #62.

A taxonomic composition similar to that at station 61 is found at station 40, except Cladocera, Foraminifera and Thaliacea. Total abundance of plankton is half of that at station 61, but the major groups are the same: Decapoda, Chaetognatha, Appendicularia and Mollusca.

Summing up these first results from zooplankton composition, three or four major areas may be defined coinciding with the hydrographic regime. A set of stations in the northeast, east and southeast, where plankton is influenced by the warm and oligotrophic BC water masses. A second set of stations in the southwest, within the 25°C-isotherm, dominated by the colder and more nutrient rich water masses of the MC outflow. A third group of stations in the centre of the area, on the top of the Abrolhos shelf, which represents a mixing area between the "BC-community" and the "MC-community". It has to be proved, how far and strong the influence or range of MC-waters are at the stations in this area. A fourth community may come up at nearshore stations like #11, *which may be influenced by riverborn waters, rich in nu*trients and other organic and inorganic material from adjacent mangrove areas.



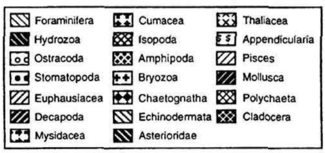


Fig. 4: Composition of the non-copepod zooplanktonfraktion at five selected stations: 18, 19, 40, 61 and 62

Further analysis will concentrate on selected taxonomic groups to describe their distribution in correlation to the water masses and elucidate the processes of transport and mixture between the two dominant water masses in the area.

Ichthyoplankton

Objectives

The continental shelf of the Abrolhos region is covered by the nutrient deficient tropical waters (Brazil current) and the thermocline is formed below 150 m depth. Thus, the nutrient input in the euphotic zone is *limited at some localized areas of upwelling, vortex or continental river outflow.*

In spite of the oligotrophic environment, the area is characterized by the rich demersal fish fauna which sustains a commercial fishery by hook and line.

The project proposed here has the objective to investigate the influence of this peculiar oceanographic configuration on the distribution and abundance of the fish larvae and recruitment mechanism of the demersal and pelagic fish.

Methods

For the analysis of the fish larvae distribution, samples were collected with Bongonet. At each station, one integrating Bongo haul was made down to 200 m or to 5m above the sea bottom. Mesh size used was 300 and 500 µm. In total 58 samples could be taken.

The samples were conserved immediately after the catch in 4% formalin. In the laboratory total biomass of the catches was estimated as wet weight in $mg{*}m^{-3}$. Taxonomic classification up to now was done to family level. Results are presented in the following.

Results

Total biomass in the Bongonet catches (500µm) varied between 20 and 844 $mg{*}m^{-3}$. Corresponding to the biomass distribution in the 300 µm-net (fig. 3), distribution of biomass in the 500µm-net follows the isotherms very clearly as well. High biomass values (>200 $mg{*}m^{-3}$) are found near the coast in areas, where temperature in 50m water depth does not exceed 25.5°C, this is at stations 11, 21, 22, 35, 36, 52 and 53. With increasing water temperature in the southeast, east and northeast, total biomass decreases below $120 mg*m^{-3}$.

Highest biomass of 844 $mg*m^{-3}$ is found at the Abrolhos coral reef station #22. All high biomass values were found in the influence of the MC-offshoot waters, where temperature is lowest (< 24°C). High biomass values in the north at stations 11, 21 and 22 may be induced by terrigeneous input of nutrients, which come from small mangrove bordered rivers between Belmonte and Caravelas.

A total of 10512 fish larvae was caught with one Bongo net and analysed for taxonomic composition. More than 60 taxonomic groups could be identified on the family level. This indicates a very high diversity within the fish larvae. Most abundant group in the catches was the mesopelagic one with 4053 specimens, including Myctophidae, Gonostomatidae and Stomiatidae. Other dominant families were Gobiidae, Scaridae and Serranidae (1618, 1156 and 822 specimens caught), and with some less importance Engraulidae and Callionymidae (381 and 355 specimens, respectively). Twelve families (Bregmacerotidae, Clupeidae, Bothidae, Cynoglossidae, Soleidae, Paralichthyidae, Apogonidae, Paralepididae, Carangidae, Synodontidae, Labridae, Chiasmadontidae) were found at numbers between 100 and 200 specimens in the catches.The other groups were of less importance with less than 100 specimens caught.

Obvious is the high abundance of mesopelagic speciesmainly at the deep stations. They represent 38,6% of the total amount of caught larvae. This indicates the strong influence of the Central Atlantic Mid water occurring below the thermocline at about 150 m depth. Mesopelagic fishes are of great importance as food for many other fishes in the region. Tunas and other scombrid fishes come to this area for feeding and spawning.

The second dominant group are the Gobiidae. They are typical shallow water species in the tropics and subtropics. Scaridae or parrotfishes are typical reef fishes and in this study obviously linked to the Abrolhos reefs. Serranidae are large, piscivorous fishes associated with tropical reefs and inshore environments. These three families are fully demersal and form a contrasting group to the mesopelagic taxa in the samples.

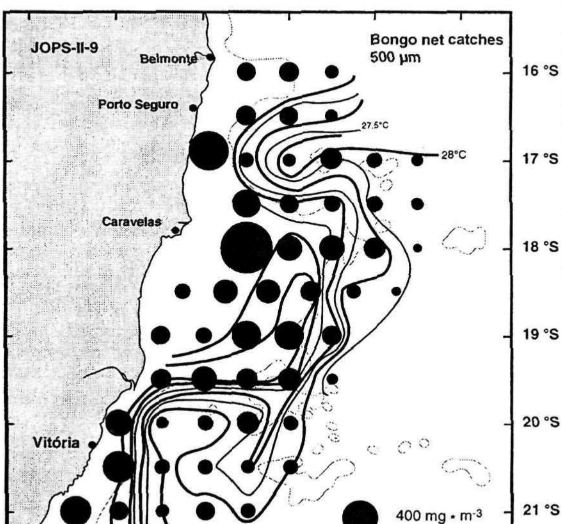


Fig. 5: Zooplankton biomass in 500 µm Bongo catches in $mg*m^{-3}$

Much less abundant are Callyonymidae, Bregmacerotidae and the pleuronectiform families. Callyonymidae (dragonets) are known as small reef related fishes, which live on the bottom in coastal waters, some occur in tidal pools and coral reefs. Bregmacerotidae are small benthic species from medium deep water layers. Pleuronectiformes include all the benthic flatfish species, which occurre on the shelf. Together with the Apogonidae (cardinal fishes) these demersal fish groups represent about 42,7% of the caught specimens.

Remarkable is the low abundance of clupeid species (Clupeidae and Engraulidae, together 5,4%), which is in great contrast to the southeast Brazilian coast up to Cabo Frio/Cabo de Sao Tomé. This indicates the generally weak

Tab. 2: List of taxonomic groups of fish larvae found in Bongo catches during JOPS-II-9.

Taxon	number of larvae	Taxon	number of larvae
Mesopelagics: (Myctophidae, Gonostomatidae, Stomiatidae,etc.)	4053	Aulostomidae	18
Gobiidae	1618	Cirrhitidae	18
Scaridae	1156	Gempylidae	18
Serranidae	822	Tetraodontidae, Diodontidae	16
Engraulididae	381	Mullidae	13
Callionymidae	355	Carapidae	12
Bregmacerotidae	187	Holocenturidae	11
Clupeidae	183	Sphyraenidae	11
Pleuronectiformes: (Bothidae, Cynoglossidae, Soleidae, Paralichthyidae)	180	Syngnathidae	11
Apogonidae	169	Triglidae	10
Paralepididae	132	Coryphaenidae	8
Carangidae	132	Antennariidae	7
Synodontidae	127	Ostraciidae	6
Labridae	124	Microdesmidae	5
Chiasmadontidae	124	Fistularidae	5
Balistidae + Monacanthidae	89	Gerreidae	3
Anguilliformes (leptocephalus)	84	Hemiramphidae	2
Scorpaenidae	78	Opistognathidae	2
Lutjanidae	70	Elopidae	2
Pomacentridae	64	Pomatomidae	2
Pomacanthidae	45	Priacanthidae	2
Ophidiidae	44	Istiophoridae	1
Blenniidae	31	Ogcocephalidae	1
Trichiuridae	28	Scombridae	1
Acanthuridae	25	Scombrolabraxidae	1
Sciaenidae	23	Tripterygiidae	1
		Echeneidae	1

indluence of the colder MC waters.

The relation between pelagic (Clupeidae and Engraulidae) and bottom dwelling (s.a.) groups of fish larvae demonstrates the high significance, demersal species play in this area. Pelagic habitat is poor in general and higher production is limited to local upwellings and shallow areas influenced by coastal inputs.

Fish larvae were present at all stations, total abundance in the 500 µm net is shown in fig. 6 as larvae per m^2. Highest amounts of larvae are found along the shelf edge. Temperature does not seem to have too much influence on the distribution pattern. Generally the amount of larvae near the shelf edge was between 100 and 1000 larvae per m^2. The highest density was found at station 31, located in the neighbourhood of the Abrolhos coral reefs.

The distribution patterns of the four dominant taxonomic groups (Tab. 2) show specific differences.

The **mesopelagic** species are distributed quite equally at the deeper stations (fig. 7). They do rather not appear on the shelf. Abundances in water depths less than 100 m are low, at the very shallow stations the group is lacking. This can be related to the normal depth distribution of mesopelagic species, preferring depths of 200 to 400 m as

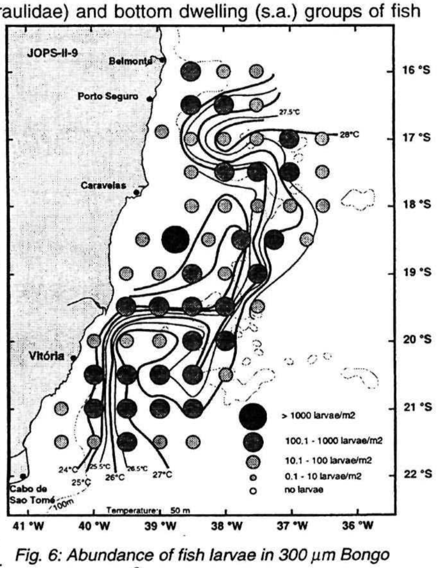


Fig. 6: Abundance of fish larvae in 300 µm Bongo catches in n*m^{-2}

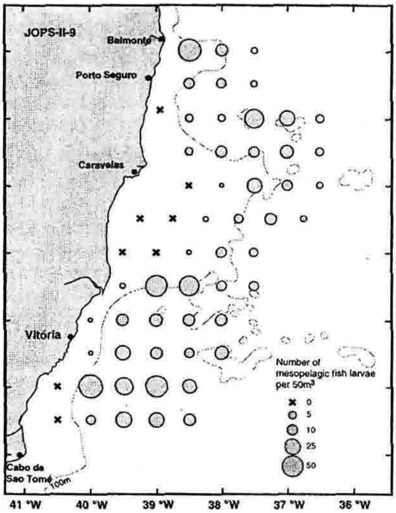


Fig. 7: Abundance of mesopelagic fish larvae in 300 µm Bongo catches in n*50m^{-3}

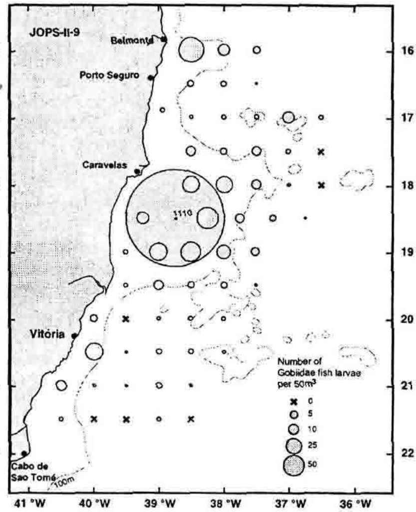


Fig. 8: Abundance of Gobiidae larvae in 300 µm Bongo catches in n*50m^{-3}

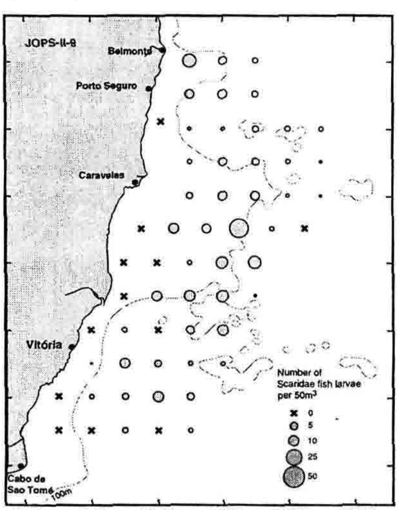


Fig. 9 Abundance of Scaridae larvae in 300 µm Bongo catches in n*50m^{-3}

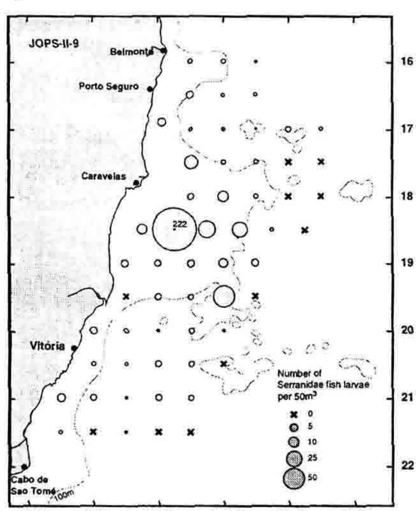


Fig. 10: Abundance of Serranidae larvae in 300 µm Bongo catches in n*50m^{-3}

adults, younger stages appearing also near the surface, but always above deep waters.

Gobiidae are abundant mainly at the shallow stations at water depths less than 100 m (fig. 8). The highest concentration was found at station 31 near the Abrolhos reefs with 1110 specimens per m^3.

Only few specimens appear outside the shelf area, assuming that these are driften offshore occasionally by the different water currents.

Scaridae occurred only in lower concentrations, mainly at the offshore stations (fig. 9). Slightly higher concentrations were found only near the shelf edge.

Serranidae, similar to the Gobiidae, were found mainly on the shelf plateau (fig. 10) with its highest concentration at station 31 near the Abrolhos reef with 222 specimens per m^3. These findings coincide with the ecology of the species. Serranidae are typical piscivorous fishes associated with tropical reefs.

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9	Huxol, Werner	electrician	10.12.-22.12.94
10	Konrath, Rolf	electrician	28.12.-8.4.95
11	Trammitz, Hans-J.	electrician	10.4.-8.5.95
12	Tiemann, Frank	cook	10.12.-22.12.94
13	Grün, Franz	cook	28.12.94-8.4.95
14	Jahns, Winfried	boatswain	10.12.-23.1.95, 10.4.-8.5.95
15	Baron, Heiko	boatswain	25.1.-26.3.95
16	Mahlmann, Detlef	sailor	10.12.-23.1.95
17	Krüger, Helmut	sailor	25.1.-8.5.95
18	Lentzen, Peter	sailor	10.12.-22.12.94
19	Hoffmann, Werner	sailor	28.12.-23.4.95
20	Spille, Hergen	sailor	25.4.-8.5.95