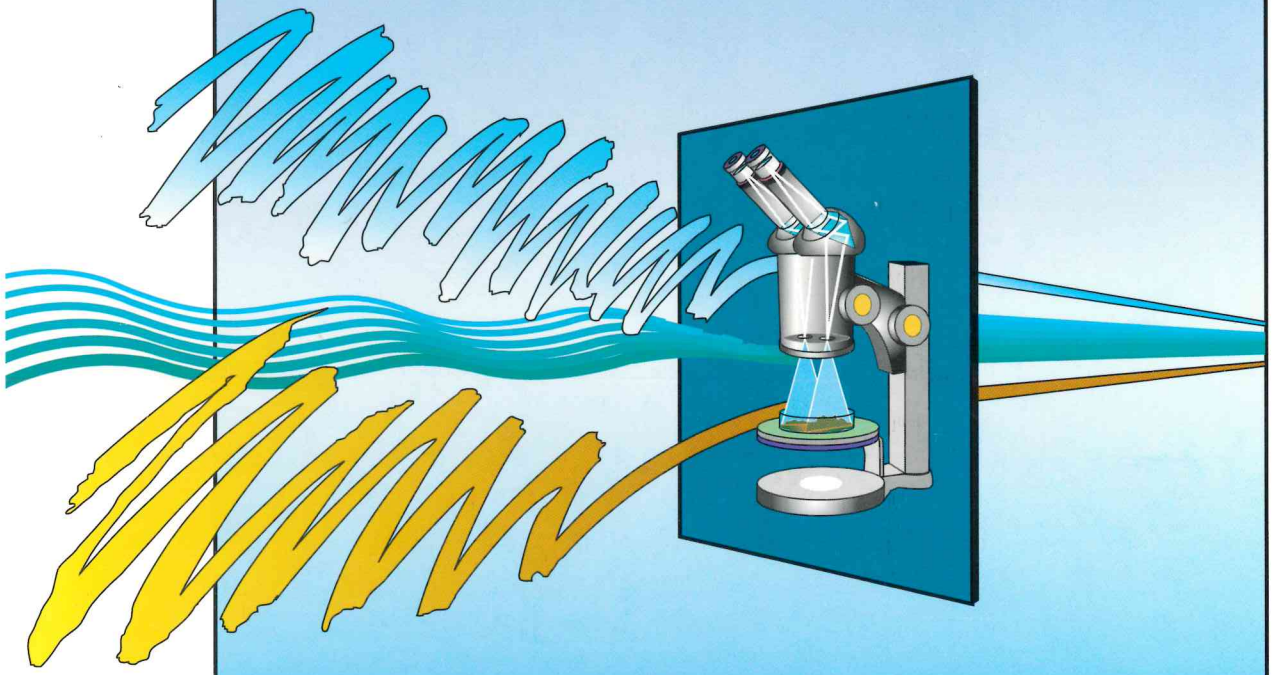
ANNUAL Report 1995



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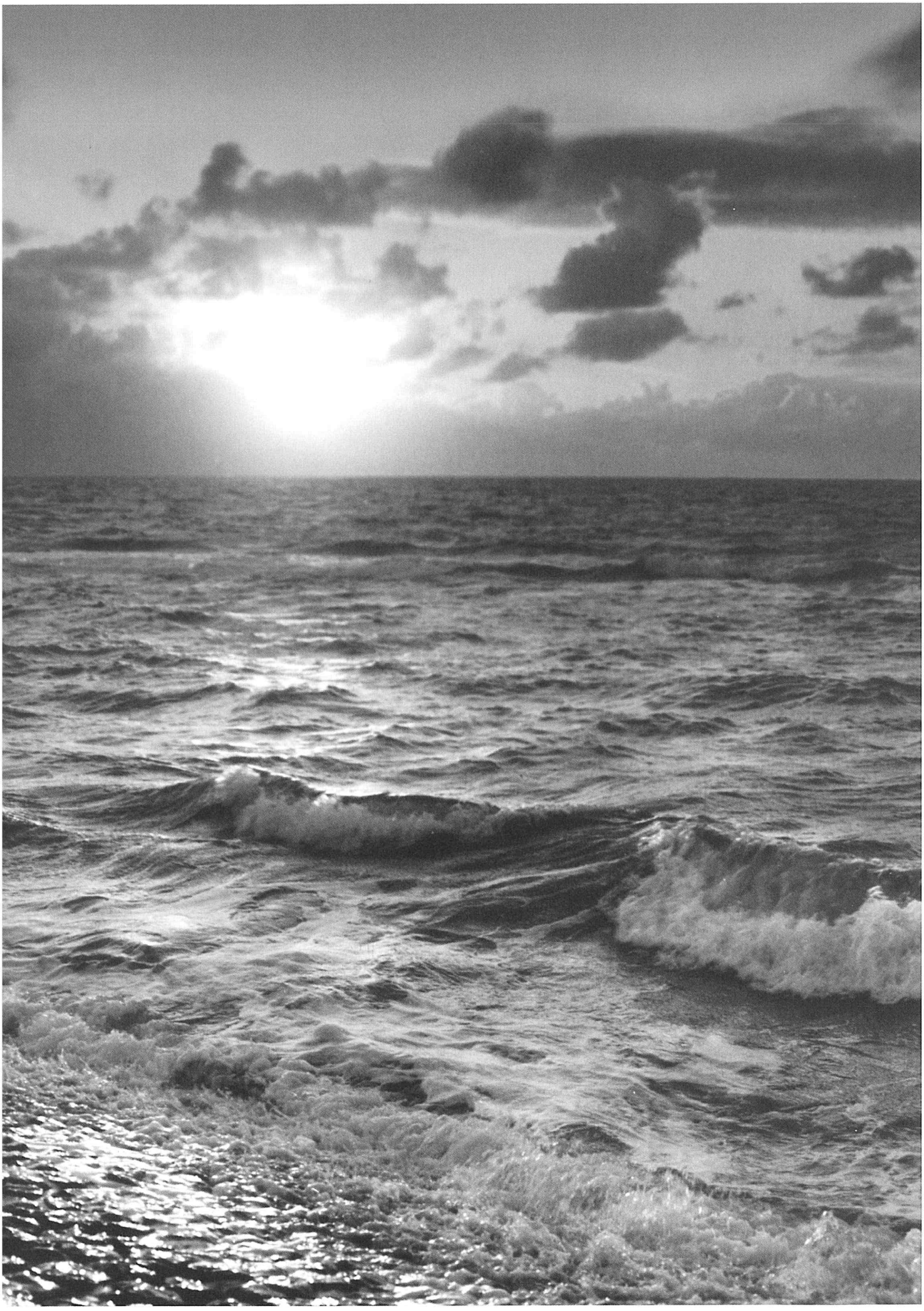
ANNUAL REPORT 1995

NETHERLANDS INSTITUTE FOR SEA RESEARCH (NIOZ)



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INTRODUCTION

The year 1995 was a year of unremitting scientific activity. With the RV Pelagia relatively large expeditions were undertaken to the Celtic Sea and the Bay of Biscay, the latter to execute the European Union Ocean Margin Exchange programme (OMEX) and the Dutch World Ocean Circulation Experiment (WOCE) contribution, both financed by GOA, the Earth Science Division of the Netherlands Organisation for Scientific Research (NWO). Several other cruises were made to various parts of the North Sea, although less frequently than in previous years because of limited funds. One project which required quite some effort is the Mooring Project, part of the Integrated North Sea Programme which started in 1991 and studies the relations between the various biological and physical parameters.

It seems now that the scientific activity of NIOZ was hardly affected by an operation which was started in 1994 and resulted in a formal reorganization in the period under review.

The internal structure of NIOZ was reshaped, mainly according to the advice of the Anderson, Elffers and Felix (&AEF) consultancy. The outcome as well as the straightforwardness and sincerity of their approach was much appreciated by the board and employees of NIOZ. Although the changes were rather drastic, they were completed in a relatively short time and in good co-operation between the board, the director and the employees council.

The reorganisation concerned the directorate, the financial department and the scientific departments. The almost 100 scientists and assistants have been allocated to five instead of the former eight departments. This meant a radical change to many, including the new department heads, who now have to bear larger responsibilities for the scientific as well as the organizational management of their department. Only the composition of Physical Oceanography remained unaffected. Chemical Oceanography and Marine Geology have been combined into the department of Marine Chemistry and Geology. The marine toxicology group joined the biogeochemists in a department now called Marine Biogeochemistry and Toxicology. The former Pelagic Systems department has in effect been renamed Biological Oceanography, whereas the majority of the members of the departments of Benthic and of Coastal Systems are now united in the new department of Marine Ecology.

A breaking point with the past is the fact that the group of scientists and technicians devoted to policy-linked marine research, BEWON, has ceased to exist as a separate department. As this type of research is, however, still part of the formal task of NIOZ, the research projects and the scientists and assistants concerned have been integrated into the new departments.

The technical services were reorganized some years ago and have therefore been left unchanged.

Details on the new structure of NIOZ are given in chapter 5 of this report.

In early 1995 more advice from the consultants of &AEF was received which now caused serious concern about the financial situation of the institute. It was decided to accomplish the qualitative reorganisation which was planned as described above, before new plans were made to cope with the financial shortages. This was completed by 1 July.

The new plans were completed by early November and submitted to the board of NWO with a request for financial assistance. The final decisions and their execution have been postponed until early 1996.

The number of international cooperations, especially those based on formal agreement, is increasing. A few years ago the European Science Foundation established a European Committee on Ocean and Polar Science (ECOPS), aimed at defining a large-scale marine and polar research programme, the Grand Challenges. In 1995 the final decision was reached and as a steering committee a group of national representatives was appointed, referred to as the European Forum.

Joint research projects with the Marine Geology Department of the University of Moscow and with the Marine Fisheries Institute of the University of North Carolina at Raleigh were continued. The intensive collaboration with the Alfred Wegener Institute für Polar und Meeresforschung (AWI) in Bremerhaven is mainly concerned with chemical, biological and physical aspects of the Southern Ocean. An initiative has been taken at government level to formalize the collaboration between the Netherlands' marine research institutes and those of the bordering countries, Belgium and Germany, in a wider framework, for Germany concerning the Stadt Bremen. As a consequence of a Memorandum Of Understanding between Indonesia and the Netherlands, NIOZ was stimulated to participate in a collaborative research project with Indonesian and Dutch colleagues in the Banten Bay, west of Djakarta. In general there is a tendency to draw the attention of marine researchers towards South East Asia, partly because of the strongly increasing activities especially in coastal research stimulated by the LOICZ programme.

The first steps have been taken towards the installation of an experimental wader study facility, with possibilities for adjusting tides as well as relatively low and high temperatures. It is anticipated that the facility will generate international and national co-operation, the latter with the Graduate School for Functional Ecology, led by the University of Groningen.

The introduction of quite a different type of demanding facility which is worth mentioning is that of the irm-GC/MS, a complicated and critical instrument which determines the carbon iso-

Photo: J. van de Kam.

topic ratio of extremely small fractions of organic matter which have first been separated gas-chromatographically by the same instrument

The free-falling bottom landers for chemical, geological and biological observation of bottom processes have again been employed intensively and successfully. They are drawing strong international attention.

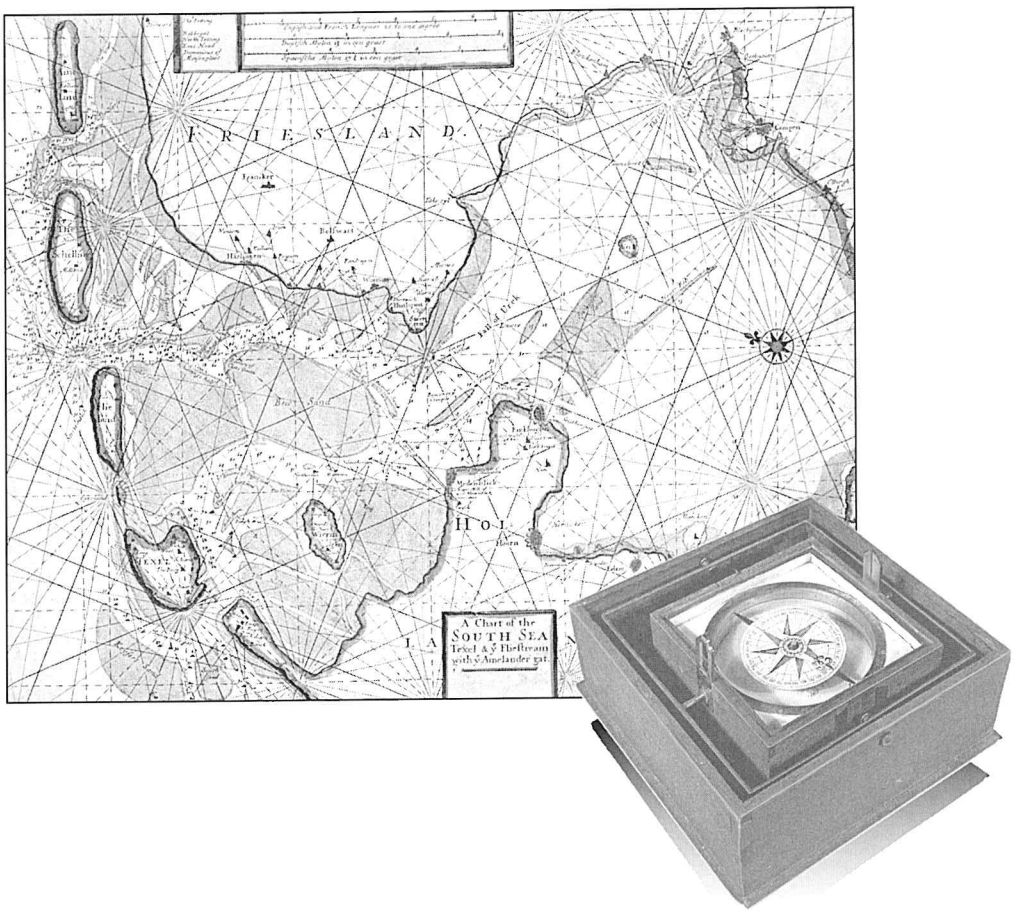
The ties with the newly established Graduate Schools in the Netherlands have become stronger. Concerning the Graduate School for Sedimentary Geology, Dr. de Leeuw, head of the department of Marine Biogeochemistry and Toxicology at NIOZ, was appointed part-time professor of Organic Geochemistry at Utrecht University, which brought the number of similar positions at NIOZ to a total of seven. Dr. de Leeuw has, furthermore, been appointed member of the Royal Netherlands Academy of Sciences (KNAW).

A total of seven PhD students received their doctorate, of which three in marine biology (University of Amsterdam), two in biogeochemistry (University of Groningen and University of Paris), one in physical oceanography (University of Utrecht), and one in marine geology (University of Utrecht). The number of current PhD projects decreased slightly, from 40 in 1994 to 35 in 1995. On the other hand, the number of refereed scientific papers increased to a rewarding total of **176**

At the conclusion of 1995, NIOZ is in a stage of renewal. The new structure has just begun to operate. Discussions have started to reconsider the formal task of the institute and its role in the national marine research community. Research themes and projects will be redefined. And finally, NIOZ has to receive a new healthy financial basis. Plans have been made but their realization requires no less effort: a healthy challenge for the institute's community and its future director.

W.G. Mook
(retired 31 December 1995)

MAPS


F R I E S L A N D.
A Chart of the
SOUTH SEA
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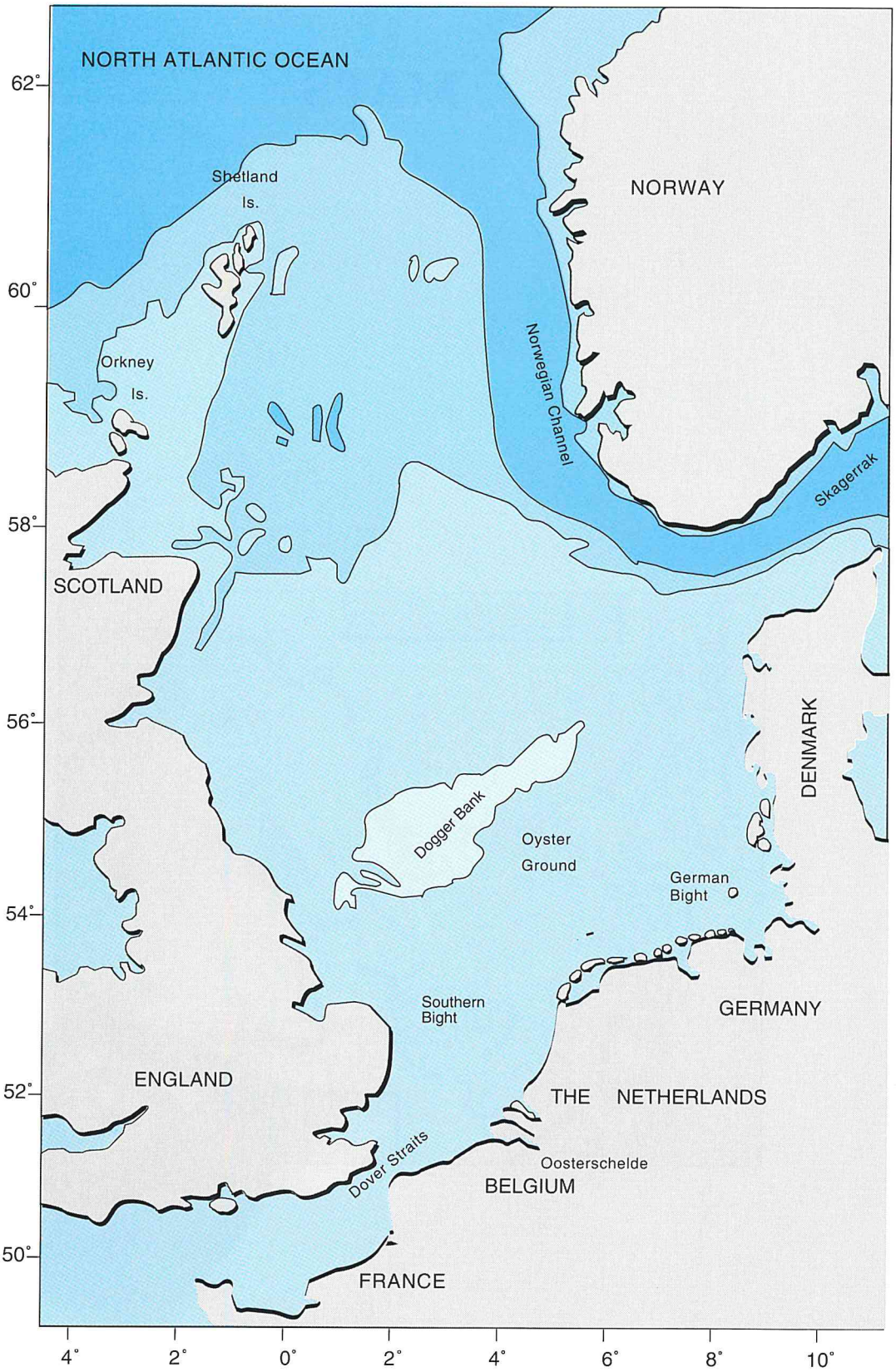
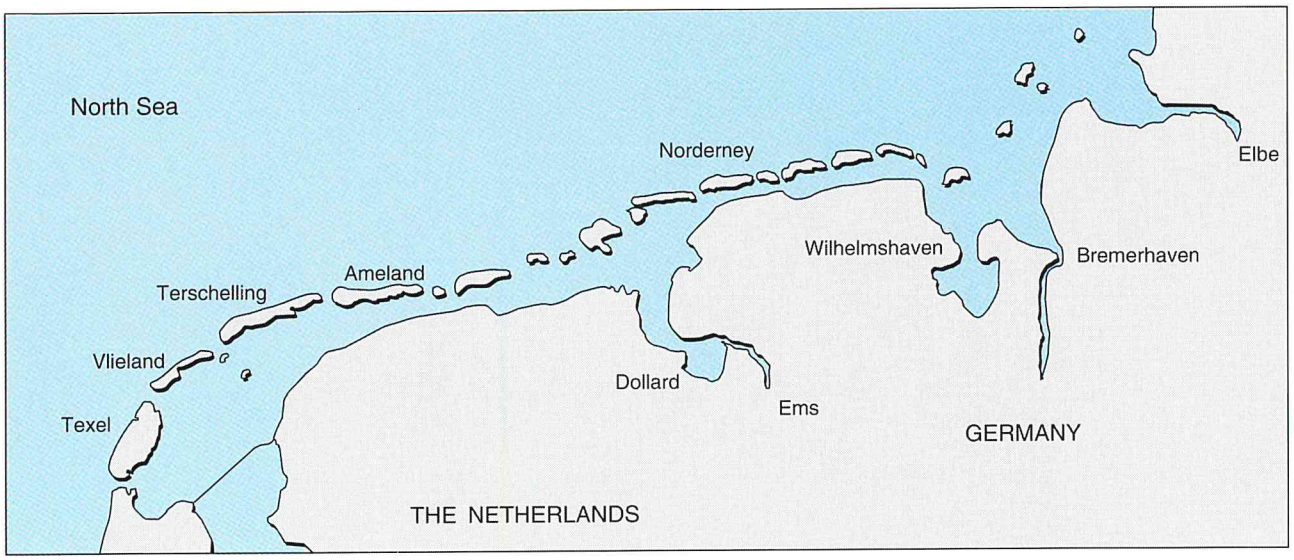
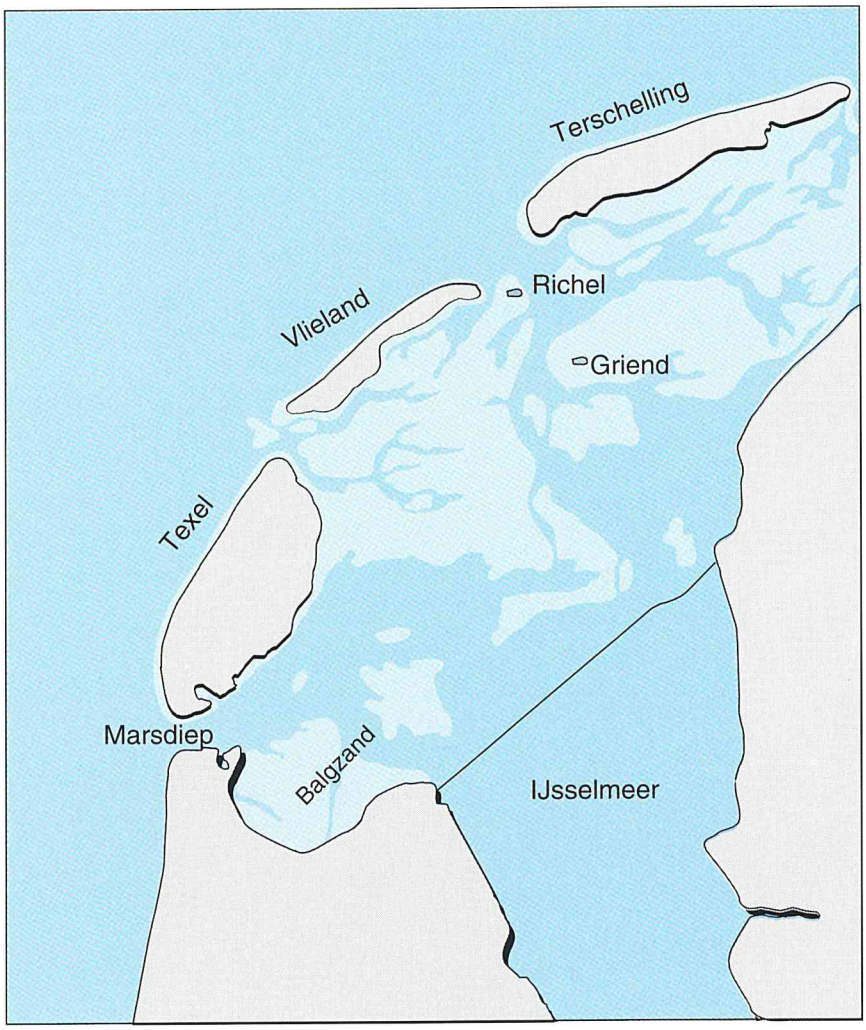
MAPS



North Sea with geographical names mentioned in this report





Wadden Sea and Dutch coastal waters with geographical names mentioned in this report

1. Scientific Activity

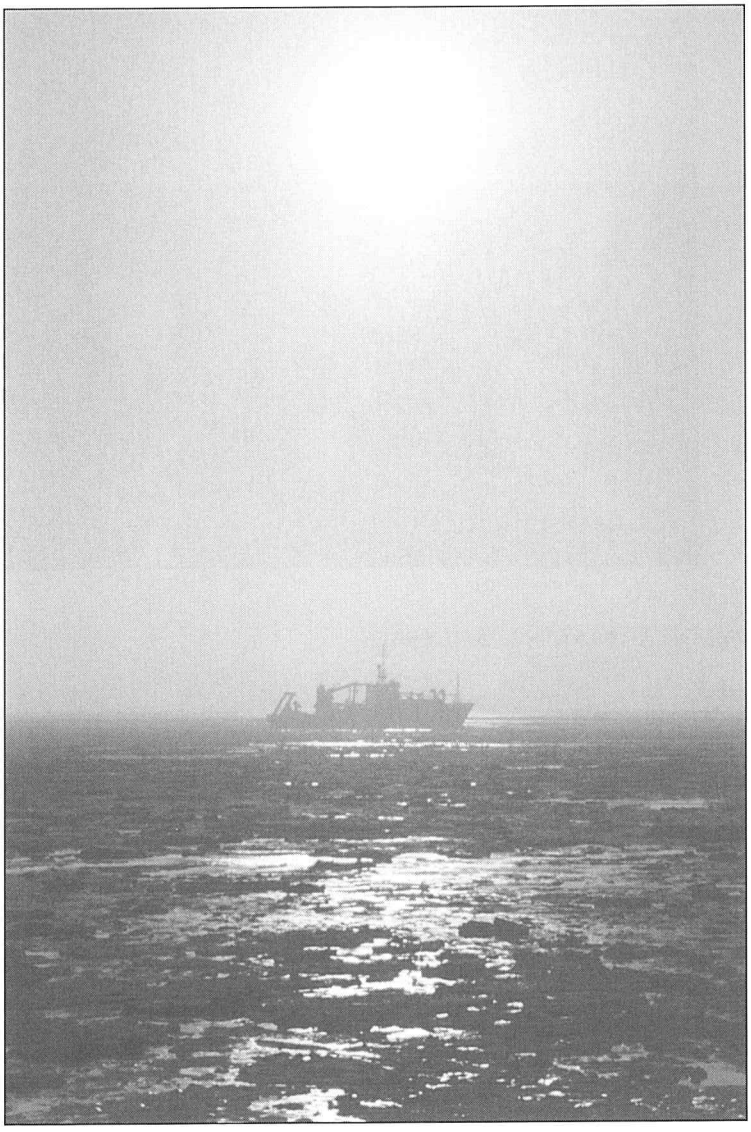


Photo: C. Blaauboer.

DEPARTMENT OF PHYSICAL OCEANOGRAPHY

The Department continued to work under the following main themes:
—1. Dynamics of (non)linear marine processes
—2. Water circulation and hydrography of the North Atlantic
—3. Physical aspects of marine ecosystems

Within the first theme theoretical studies were performed on the thermohaline circulation, oceanic monopolar vortices, chaotic mixing and internal wave focusing. The study of chaotic mixing in tidal areas was completed with a thesis.

As a part of theme 2, the TripleB (Bay of Biscay Boundary) programme was started with a four-week hydrographic survey with RV 'Pelagia' in the Bay of Biscay in the summer of 1995. During this cruise a large number of CTD/rosette casts were occupied and an array of current meter moorings deployed on a line perpendicular to the continental slope. Additionally, yo-yo stations were occupied showing trains of internal solitons coupled with the tidal phase.

Multidisciplinary projects in which the Department was involved were the study of the biological and physical factors affecting erosion/sedimentation of cohesive sediments in the Dollard, the INP-mooring project, the JGOFS/Southern Ocean project and the application of marine optics. To analyse the biological and physical factors affecting erosion/sedimentation of cohesive sediments, a numerical model was developed. For the INP-mooring project and JGOFS/Southern Ocean project, 1995 was the year of data analysis.

Four generations of NIOZ scientists who completed a thesis on mixing in the Wadden Sea. From right to left: Prof. Dr. H. Postma (1954), Dr. S.P. Beerens (1995), Prof. Dr. J.T.F. Zimmerman (1976), and Dr. H.J. Ridderinkhof (1990).

Photo: T. de Bruin.

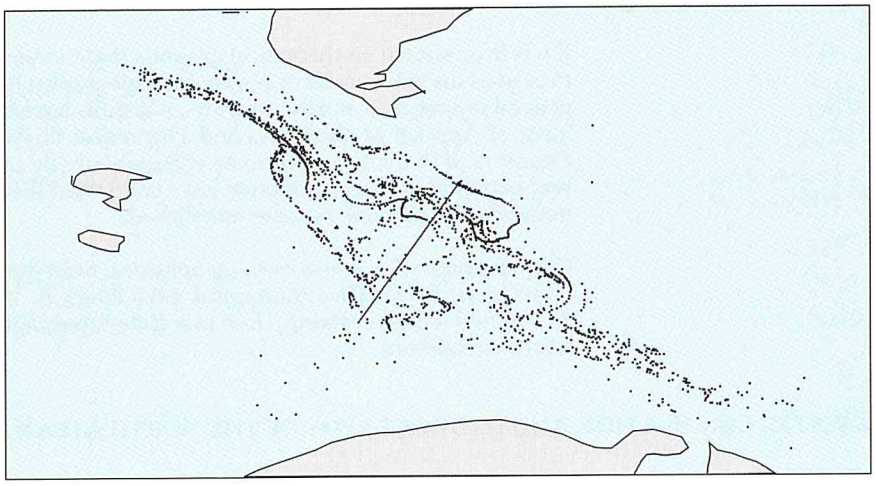
1. DYNAMICS OF (NON)LINEAR MARINE PROCESSES

Thermohaline circulation

A simple model of the thermohaline circulation has been developed, coupling the lowest moments of the momentum field with those of the temperature and salinity fields on an f-plane. The thermohaline circulation is driven by applying boundary conditions for temperature and salinity at the surface. The formulation of the boundary conditions is a delicate matter since it is the source of variability of the ocean circulation. In contrast to previous studies where the boundary conditions for temperature and the salinity flux were prescribed, the salinity flux at the surface is now coupled with the ocean's temperature. This results in the existence of multiple steady states (a thermal and a haline driven circulation). Increased forcing turns these steady states periodically through a Hopf bifurcation and, via a cascade of period doubling bifurcations, leads to a chaotic state.

Oceanic monopolar vortices

A physically consistent, highly precise (rms error 0.07%) description of the terrestrial gravity field has been proposed. This gravity field completely compensates the horizontal component of the

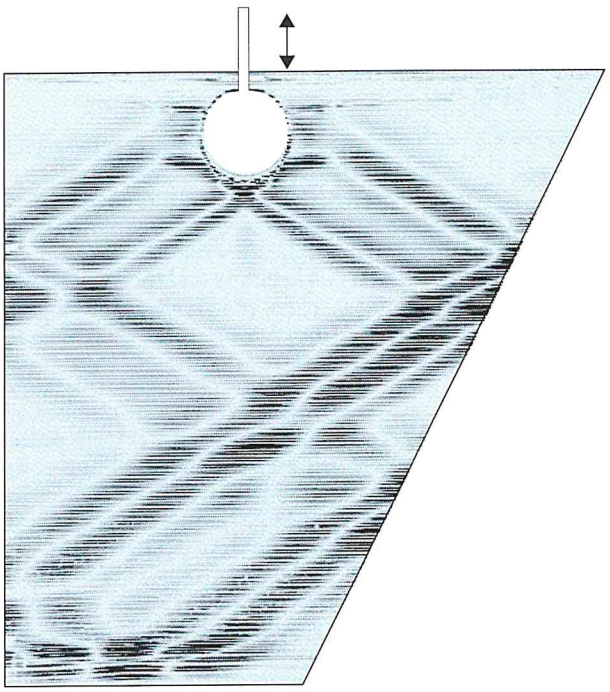


Depicted is the chaotic advection of a line of 1000 particles, indicating rapid mixing of the tidal area. These particles were initially released in an eddy located in the tidal channel of the Ems estuary, a shallow tidal area in the eastern Dutch Wadden Sea and are shown after 0, 1, 2, 3 and 4 tidal periods.

centrifugal force, due to the spin of the earth, at the surface of the earth. This compensation, which in reality is due to the oblateness of the earth, may thus also be implemented in a perfectly spherical model. It explains why, notwithstanding the earth's spin, the oceans are not dramatically deeper in equatorial regions than they are around the poles. This spherical model consistently formalizes the belief that, apart from circumstantial details, in the real ocean spherical symmetry is essentially only broken by the β effect and is thus likely to explain the global westward motion of isolated oceanic vortices.

Chaotic mixing

In shallow tidal areas such as the Wadden Sea, the nonlinear interaction of the tidal currents and irregular bottom topography generates (residual) currents, which are often organized in eddy-like structures. Simplified models have shown that advection in a current field composed of a tidal and an eddy component is chaotic. Using a realistic model of Ems-Dollard estuary it was demonstrated that this chaotic advection can explain the observed horizontal dispersion of particles. The horizontal variability in dispersion coefficients in this estuary, as deduced from salinity measurements in the past, appears to be closely related to the distribution of residual eddies.



A typical example of the visualization of internal waves as used in the experimental set-up in the laboratory of the Department of Applied Mathematics & Theoretical Physics (DAMTP) in Cambridge. Shown is a cross-section of a container filled with water of linearly varying density: 1025 $kg \cdot m^{-3}$ near the surface and 1102 $kg \cdot m^{-3}$ near the bottom of the tank. Internal waves are generated when the cylinder starts oscillating. As a result, fluid is displaced and differences appear in the refraction index of fluid at one horizontal plane. The patterns intrude into the fluid away from the oscillating cylinder at an angle depending on the density gradient and the frequency of the oscillation. The downward intrusion can be seen on the picture, while black & white phase lines move diagonally upward at the same time. Both are basic properties of internal gravity waves in a continuous density-stratified medium. The picture also shows that the beam reflecting at the sloping boundary is smaller after reflection, while this is not the case after reflection at the vertical side wall of the tank. The behaviour of these patterns after several (or numerous) reflections is predicted in Maas & Lam (1995).

Internal wave focusing

It has been shown on theoretical grounds that monochromatic, internal wave eigen-modes cease to exist as discrete modes over variable topography. It has also been shown that internal waves in general propagate towards attractors. Attempts have been undertaken (with the aid of the Department of Applied Mathematics and Theoretical Physics, Cambridge University and the Physics Department of the École Normale et Superieure de Lyon) to verify these predictions in a laboratory experiment. These attempts have confirmed the predictions and made clear how these stationary wave patterns become established.

Contributors: *J.T.F. Zimmerman* (geophysical fluid dynamics), *L.R.M. Maas* (geophysical fluid dynamics), *H. Ridderinkhof* (numerical modelling), *R. Van der Toorn* (geophysical fluid dynamics), *S.P. Beerens* (chaotic mixing), *F.-P. Lam* (tide-topography interactions), *G. Van der Schrier* (thermohaline circulation).

2. WATER CIRCULATION AND HYDROGRAPHY OF THE NORTH ATLANTIC

Northeastern Atlantic

The study of the northeastern North Atlantic Ocean was initiated with the DUTCH-WARP programme in 1989-1991. This year a data base has been set up with hydrographic data collected between 1983 and 1991 by Dutch, German, British, American, French and Norwegian ships over the Porcupine Abyssal Plain, in the Iceland Basin, the Rockall Channel, and the southeastern Norwegian Sea. The combined physical and chemical hydrographic data allow a thorough analysis of the distribution of northeastern Atlantic water types in property-property space as well as on isopycnal surfaces.

The Subpolar Mode Water (SPMW), formed in winter by progressive cooling and freshening of water originating from the North Atlantic Current, shows a wide range of hydrographic parameter values. The warmest and most saline SPMW ($\Theta \approx 10.5^{\circ}C$, $S \approx 35.5$) with the lowest nutrient content is observed near the Porcupine Bank, west of Ireland. Further to the north and west the SPMW is fresher and colder, with the freshest SPMW ($\Theta < 6^{\circ}C$, $S < 34.95$) near 30°W, south of 55°N. North of this latitude near 30°W more saline ($S \approx 35.0$) SPMW is found at similar temperatures. Isopycnal mixing with thermocline water may be partly responsible for the modification of SPMW in the Iceland Basin.

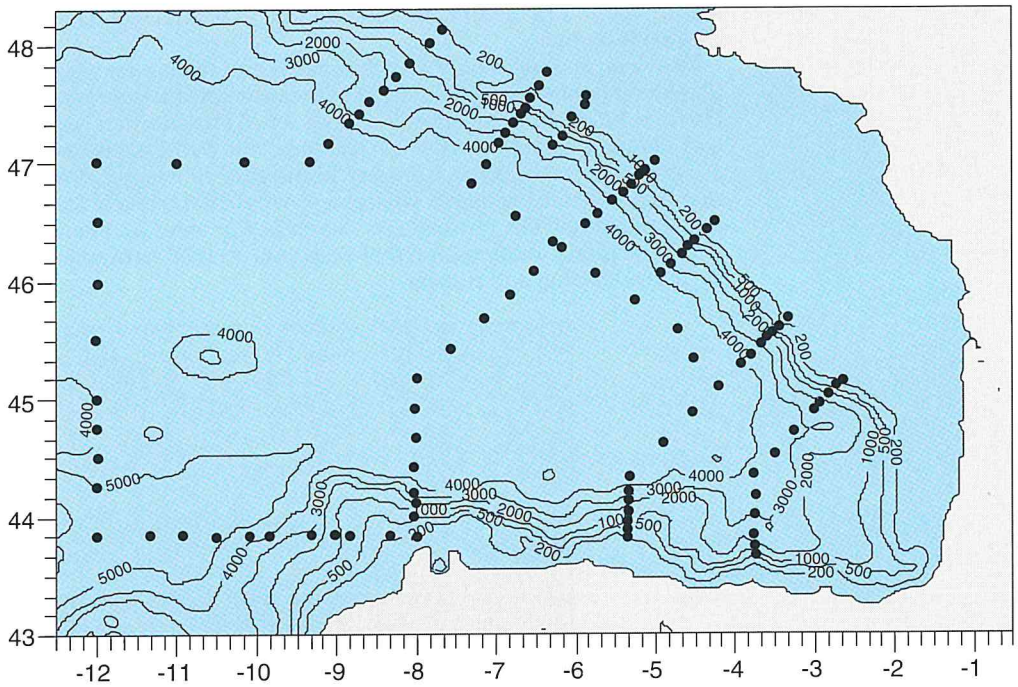
Based on optimal mass conservation a level of no motions was determined close to the $\gamma_\Theta = 27.725$ kg·m^{-3} surface in seven boxes enclosed by hydrographic sections. The geostrophic circulation, as determined relative to this potential density surface, agrees qualitatively and quantitatively with the circulation determined with surface drifters and current meters. Geostrophic transports in the near-surface layers show a through-flow of 7 Sv (1 Sv=10^6 m^3·s^{-1}) of SPMW from the northeastern North Atlantic across the Iceland-Scotland Ridge towards the Norwegian Sea, while by entrainment of SPMW into the cold water masses near the Iceland-Faeroe Ridge 3 Sv of SPMW appear to be removed from the surface layer.

Bay of Biscay

Following two preliminary cruises in 1992 and 1993, the TripleB (Bay of Biscay Boundary) programme was started with a four-week hydrographic survey with RV 'Pelagia' in the summer of 1995. During this cruise a total of 106 CTD / rosette casts were occupied. At some of the stations a high-accuracy Sea Bird Electronics electronic reference thermometer was tested. This reference thermometer, as well as the Sensoren-Instrumente-Systeme electronic reversing reference thermometers and the primary CTD temperature sensor, was calibrated with specially designed H_2O triple point cells. Preliminary analyses of the basic hydrographic data suggest the existence of a northward sub-surface baroclinic jet over the continental slope with typical velocities of 20 to 40 cm·s^{-1}. An array of eight long-term current meter moorings were deployed on a line perpendicular to the continental slope extending to the abyssal plain, and ten surface drifters were also deployed. At two positions over the continental slope, CTD yo-yo stations were occupied. At one of these stations 600 CTD profiles from 10 to 130 m were recorded over 25 hours. These showed trains of internal solitons coupled with the tidal phase, which were also observed over the nearby continental shelf with two short-term thermistor string moorings. During the other yo-yo station 104 CTD profiles in the lowest 400 m were obtained in 13 hours over the continental slope at a water depth of about 1300 m. These showed a large internal wave of semi-diurnal character with a vertical amplitude of the isotherm depth of about 100 m, 250 m above the bottom. Additionally, a benthic lander fitted with up- and downward looking ADCPs and two fast responding thermistor strings were deployed, and recovered after three weeks. The measurements of the vertical current and temperature structure covering a range of 50 m above a steep (20 degree) bottom slope of the continental shelf edge are used to reveal the vertical momentum and buoyancy fluxes. The bound-

ary layer near a sloping bottom may have a major influence on the ocean's interior density structure (due to 'boundary mixing') and on its circulation, because of the arrest of the Ekman layer by buoyancy forces.

Contributors: *H.M. Van Aken* (ocean hydrography), *C. Veth* (ocean hydrography), *J.J.M. Van Haren* (ocean hydrography and instrumentation), *F.-P. Lam* (tide-topography interactions), *S. Ober* (instrumentation and standards), *M. Manuels* (oxygen instrumentation), *M. Hiehle* (salinity, data management), *J. Thieme* (instrumentation), *R.X. De Koster* (data management).



Hydrographic stations in the Bay of Biscay occupied during the TripleB cruise of RV 'Pelagia' from 18 July to 14 August 1995. At each station a CTD profile was recorded and water samples were taken for the determination of salinity, dissolved oxygen, silica, nitrate, nitrite, and phosphate.

3. PHYSICAL ASPECTS OF MARINE ECOSYSTEMS

The physical and biodynamical behaviour of mud and in tidal areas

This project is directed towards the study of biological and physical factors affecting erosion/sedimentation of fine-grained sediments in tidal areas. Several Dutch institutes are involved in this interdisciplinary project.

The participation of NIOZ is in the development and application of numerical models and in the data acquisition, especially in the measurements on currents, waves and suspended sediment concentrations.

At the beginning of 1995 field measurements were started at the permanent measurement platform over the Heringsplaat (central part of the Dollard) and at the measurement pole in the nearby gully. A PhD student was engaged to participate in the data acquisition and the development of numerical models on the effect of waves and wave-current interaction on sedimentation, erosion and suspended sediment fluxes.

Analysis of the first measurements confirmed the strong influence of wind waves on the suspended sediment concentration profiles. The field measurements will continue during 1996.

A 2D transport model for suspended sediments was developed and applied to the Ems Dollard basin with idealized geometry. Numerical experiments with this model, in which the effect of waves on the shear stress acting on the bottom was included, show that wave effects are essential to explain the observed landward increase in the concentration of suspended sediments. These experiments also suggest that erosion and sedimentation on tidal flats is highly variable in that sedimentation of fine-grained sediments only occurs during periods with calm weather and erosion during periods when wind waves are present.

INP-mooring

Within the framework of the Integrated North Sea Project (INP) a multidisciplinary mooring was deployed between November 1993 and February 1995. The mooring site is located in a seasonally stratified part of the North Sea (Oyster Grounds). The simultaneous recording of physical (oceanographical and meteorological), chemical and biological data will provide a base for a coupled

one-dimensional physical-biological model for the lower trophic levels. The study focuses on diapycnal mixing events and associated (short-term bursts of) fluxes of nutrients (and perhaps phytoplankton) across density interfaces under atmospheric forcing and/or internal (wave) breaking.

Until recently, a comprehensive data set for such a study could not be constructed, because moorable instruments capable of measuring biological parameters were not available. During the past decade a suite of newly marketed instrumentation has been added to the more conventional ship-borne instruments. Self-contained fluorometers, transmissometers, sediment traps and nutrient analysers were deployed along with current meters, thermistor strings and acoustic Doppler current profilers. Despite this advance in techniques, obtaining long-term data sets from the sea proves still to be difficult and only a few parameters have been covered over the intended 15-month period.

The data analysis is now in full progress and the familiar spring and summer/autumn phytoplankton blooms are well reflected in the near surface fluorescence data. Distinctively, the spring bloom is found to occur (shortly) before actual stratification becomes established, whereas a summer bloom is found when stratification is still well established and no obvious externally governed mixing takes place. Contrary to the general concept of a phytoplankton maximum at the seasonal thermocline depth, enlarged phytoplankton levels were found throughout the layer below the thermocline. Further data analysis will focus on the summer bloom and on the vertical structure of tidal motions, internal tides, and on tidal harmonics induced by non-linear processes such as advection and friction.

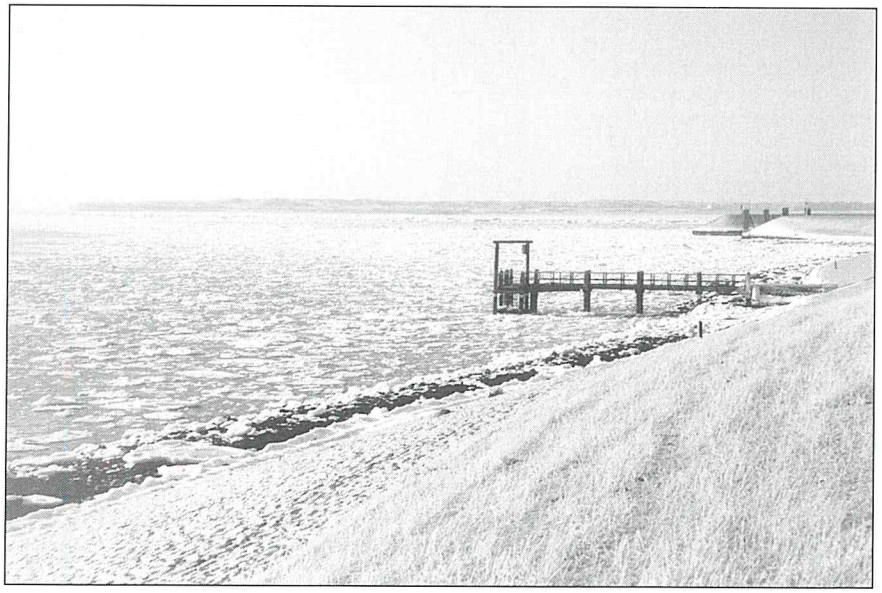
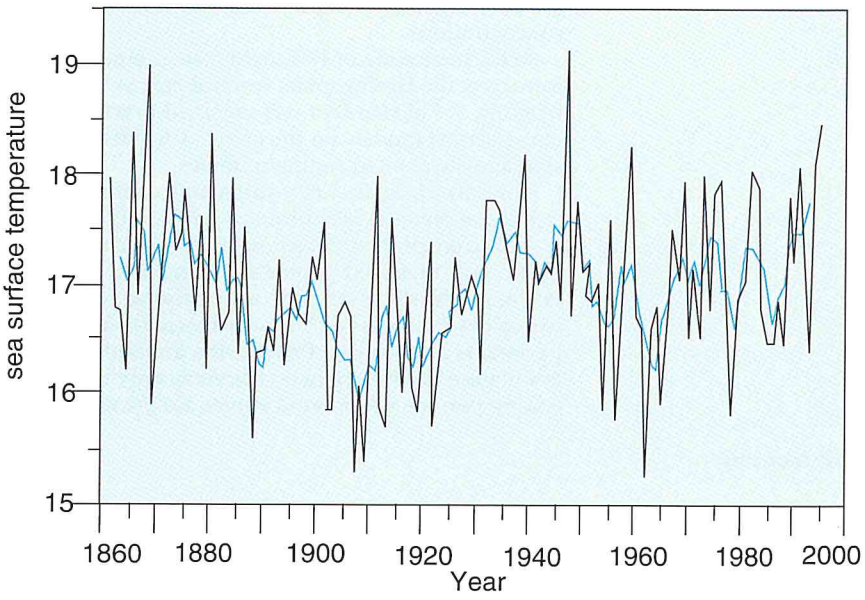


Photo: T. de Bruin.



Marsdiep time series: Since 1947 daily at 08:00 local time, sea surface temperatures have been measured, and water samples taken from the NIOZ Marsdiep pier (see picture) for salinity measurements. Monthly means were calculated to suppress the 14-day fluctuations due to the interaction of the M_2 tide and the fixed sampling time (see figure). Similar observations were carried out between 1861 and 1962 near Den Helder, on the opposite side of the Marsdiep. From the 16-year overlap, monthly mean differences of salinity and temperature have been determined by P.C.T. Van der Hoeven (KNMI). Using these differences as monthly mean corrections has enabled us to extend the Den Helder time series from 1961 to the present. Over the whole time series the warmest months are July, August, and September. In August 1995 the highest monthly mean sea surface temperature since 1861 was measured (20.4°). The runners up were August 1868 (20.2°C), and August 1947 (20.0°). The figure shows the time series of the average temperature during the warm season (July-September). In this season and over 5 consecutive years the pentad 1991 to 1995 was the warmest since 1861 (17.7°C) with the pentads 1871-1875 and 1946-1950 together on a joint second place (17.6°C).

JGOFS/Southern Ocean

The effect of secondary water motions on biological processes in the meandering flow field of the Polar Front in the Southern Ocean has been investigated. The study was based upon a combination of physical and biological data collected during the JGOFS/SO project on board RV 'Polarstern' in austral spring 1992 near the 6°W meridian. In a number of circumstances the inherent properties of algal species and pigments give additional information on small-scale physical processes that would otherwise have been difficult to determine. The secondary motions seem to play an important role in the occurrence of phytoplankton blooms in the Southern Ocean, probably by preventing deep wind mixing (co-operation with I. Peeken (Univ. Kiel), R. Scharek (Univ. Hawaii) and U. Bathmann (AWI, Bremerhaven)).

Application of the coupled physical-ecological phytoplankton growth model AQUAPHY (co-operation with C. Lancelot, Univ. Libre Bruxelles) to the whole Southern Ocean has shown that phytoplankton blooms related to a retreating melting ice-edge only occur in specific zones. It is necessary to take into account the dominant effect of wind-mixing in the calculation of the total phytoplankton production in the wake of retreating ice-edges.

Marine Optics

With the closing of the BCRS-PMNS (Particulate Matter North Sea) project newly developed ocean colour algorithms for future satellite sensors such as SeaWiFS, MERIS and NOAA were presented. During this research it was found that with ocean colour remote sensing techniques no more than three independent variables, *viz.* total chlorophyll, total suspended matter, and yellow substance can be measured.

A start has been made for the inter-annual comparison of former and present ocean colour algorithms for case-2 waters.

An interactive software package dedicated to marine optics was developed. This ODB (Optical Data Bank) can contain up to 15 different optical parameters collected above and under water and up to 30 non-optical parameters.

A 5-band reconstruction method of full spectra (visible) by means of multiple regression techniques was found as an accurate and promising method to aid the validation of remotely sensed data. This implies that ground-truth radiometers do not need adjustment of their spectral performance if new satellite sensors are introduced.

Contributors: *C. Veth* (ocean hydrography and modelling), *H. Ridderinkhof* (numerical modelling), *J.J.M. Van Haren* (ocean hydrography and instrumentation), *H.M. Van Aken* (ocean hydrography), *J. Thieme* (instrumentation), *S. Ober* (instrumentation and standards), *R.X. De Koster* (data management), *M. Wernand* (marine optics), *S.J. Shimwell* (marine optics).

DEPARTMENT OF MARINE CHEMISTRY AND GEOLOGY

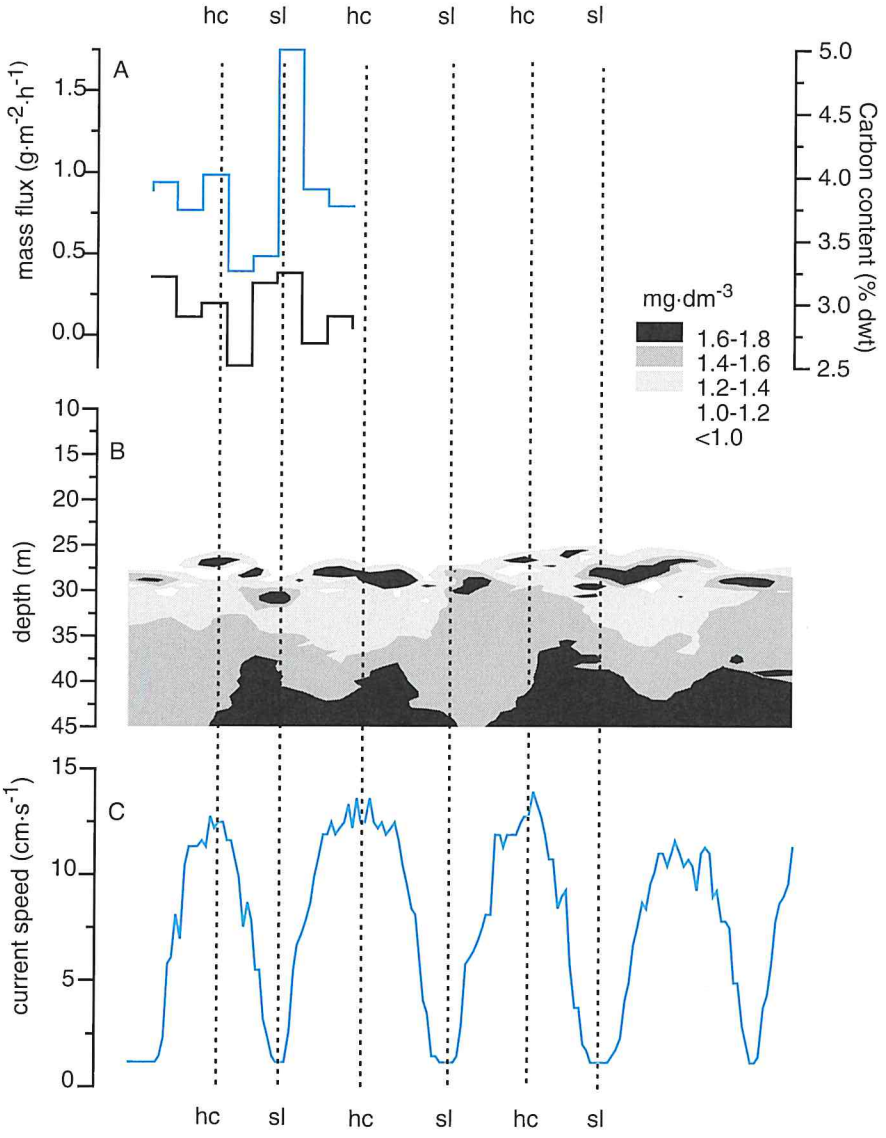
Since the reorganization of the scientific departments at NIOZ (1 July 1995) this department comprises most research items which were formerly covered in the separate Departments of Chemical Oceanography and of Marine Geology. Considerable co-operation between these two departments existed in the past, and since their combination further efforts have been made to integrate the research topics. For this annual report we use the following thematic index:

1: Biogeochemistry of carbon, nitrogen, phosphorus, and sulphur in marine systems.
2: Carbon and trace metals in the oceanic water column.
3: Palaeoceanography.
4: Sedimentation and sediment transport processes.

1. BIOGEOCHEMISTRY OF CARBON, NITROGEN, PHOSPHORUS, SILICA, AND SULPHUR IN MARINE SYSTEMS

Element cycling in North Sea sediments

The overall objective is to quantify the mineralization and burial of organic carbon in sediments as well as the associated regeneration of nutrients and metals and their sediment-water exchange rates. Research in 1995 was carried out in several programmes in the North Sea. In July the STED (Short Term Dynamics) expedition was carried out, and in the framework of the ongoing VvA



Results of a 24-h measurement series at the mooring station in the Oyster Grounds (North Sea) with:

(a) mass fluxes in a sediment trap deployed at 2 m above the sea floor (upper thick line), and the organic carbon content of these fluxes (lower thin line). The data demonstrate that mass fluxes and carbon content are largest during slack tide ('SL'), when current speed is at a minimum.

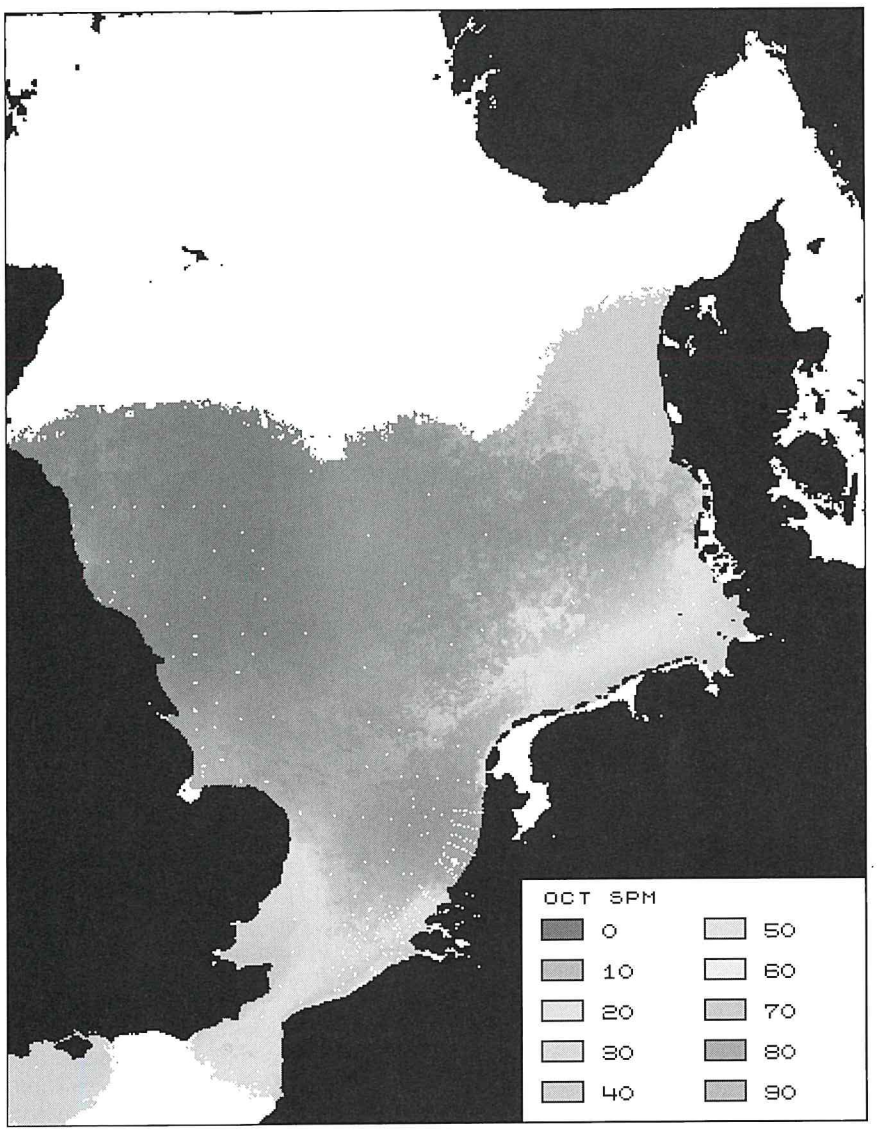
(b) suspended particulate matter (SPM) increased at increasing current speed, due to resuspension of the bottom fluff layer. Maximum mass fluxes coincided with the steepest decrease in SPM concentrations a few metres above the bottom at slack tide.

(c) current speed measured 5 m above the sea floor (hc = high current speed; sl = slack tide).

programme (Verstoring van Aardsystemen) field work was carried out in November. Within the framework of the EC-MAST-funded programme NOWESP (NOrthWest European Shelf Programme) and the SRON-funded IDA project (Integrated Data Application) the spatial distribution of SPM (Suspended Particulate Matter) in the North Sea was studied.

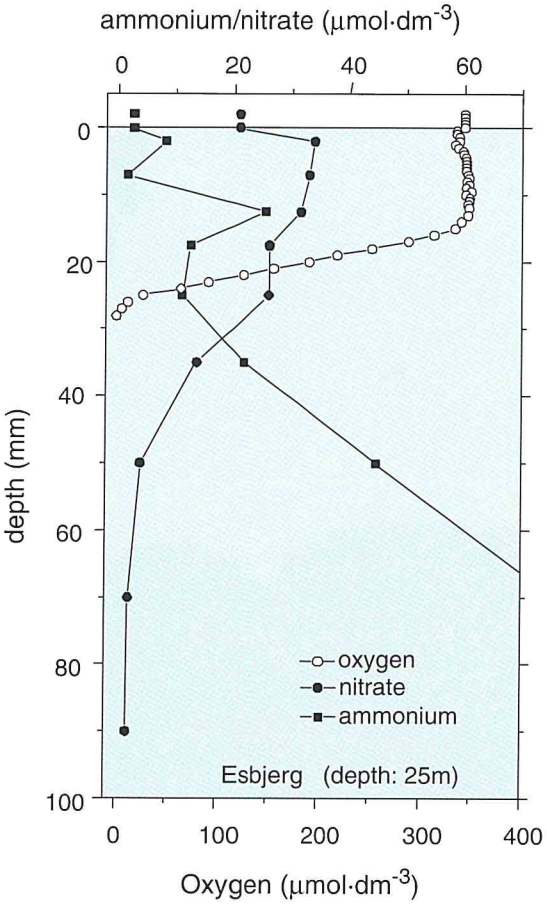
The STED expedition concentrated on a 45-m-deep mooring station at the Oyster Grounds. The aim was to search for tidal effects on the deposition of organic matter on the sea floor and the exchange of nutrients across the sediment-water interface. Since wind force was only 3-8 $m \cdot s^{-1}$ surface waves were of minor importance during STED. Transmissometer data (J.J.F. Van Haren, Department of Physical Oceanography), calibrated against SPM values obtained from Niskin-bottle samples, together with results from daily sediment trap deployments (collecting at 1-h intervals) indicate resuspension of the sediment fluff layer up to ~5 m above the bottom at (tidal) current velocities >10 - 15 $cm \cdot s^{-1}$ and deposition at slack tide, possibly through flocculation. Experiments with the material collected with the traps showed its high capacity for (de)sorption of ammonium, and indicated a release of both ammonium and nitrate of the suspended particles into the water column.

The transport and (temporary) deposition of SPM is an important process controlling the input of organic matter, particulate nutrients and sorptive clays to the sediments of the North Sea continental shelf. The sources of SPM and the time-scales of transport determine the properties of the materials upon deposition. Existing SPM data were collected from several research institutes in Europe and transferred to the NOWESP data base at the University of Hamburg (IfM). In total more than 130 000 data are available representing a period of more than 25 years. From the data we calculated the long-term average spatial distribution in the North Sea for different months, and the distribution for specific weeks.

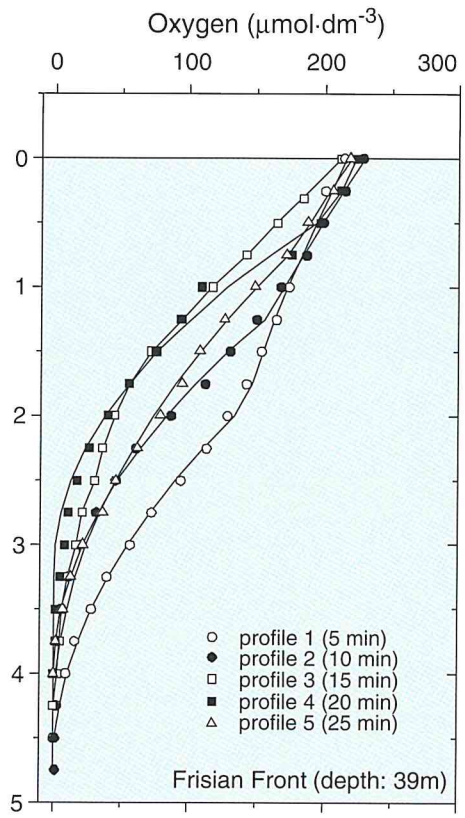


Distribution of SPM in the surface water of the North Sea for October ('climatological mean') estimated from all data available for a period between 1965 and 1993. For interpolating the data, additional information from NOAA reflection images was used. Visible is the frontal area separating the northern and central North Sea from the Southern Bight, as well as high concentrations of SPM in surface waters near the Belgian coast and closely above the Frisian Islands. Remarkable is the area of low concentrations in front of the Dutch coast. No data are available for the northern part of the North Sea.

Results on benthic oxygen consumption rates obtained during the INP-BELS cruises in August/February 1991/92 were evaluated. While rates obtained by the employment of bell-jar techniques showed a fairly good agreement with previous studies, diffusive oxygen consumption rates as measured by the application of oxygen microelectrodes revealed the occurrence of turbulent diffusion in permeable sediments characterized by non-depositional conditions. In collaboration with E. Epping (Max Planck Institute for Marine Microbial Ecology, Bremen, Germany) an advection-diffusion model was developed assuming turbulent diffusion in the upper millimetres of the sediment, while molecular diffusion was the exclusive transport mechanism in deeper sediment layers. Depending on individual sediment characteristics, the analysed oxygen profiles showed that the turbulent diffusion coefficient is 10 to 90 times higher than the empirical derived molecular diffusion coefficient in the lower layer. Verification of these oxygen profiles was obtained by comparison with redox indicative porewater compounds such as ammonium and nitrate. Suboxic diagenesis, indicated by an increase of ammonium porewater concentrations and a simultaneous nitrate decrease, started when the oxygen concentration dropped to low values. Additional evidence was derived from consecutive profiling, showing that oxygen porewater profiles were shifting towards a shape governed by molecular diffusion only after excluding the *in situ* flow regime in the sediment cores. It is suggested that in continental shelf sediments where tidal currents and wind-induced waves may affect sediment-water exchange processes, turbulent diffusion is of eminent importance in the mineralization and burial of organic matter.



Porewater profiles of oxygen, nitrate and ammonium measured in February 1992 at station 'Esbjerg'.



Consecutive oxygen profiles measured in August 1991 at station 'Frisian Front'.

Factors leading to burial of organic matter were studied in relation to benthic mineralization processes. The reported disagreement between the high pelagic primary production and the low sedimentary carbon inventory leads to the hypothesis that repeated deposition and resuspension of organic material result in a refractory carbon pool in the sediment. In co-operation with L.M. Mayer (University of Maine, USA), the organic carbon concentrations of various North Sea sediments were related to the surface area of the mineral fraction, since this sorptive protection represents a primary control on burial efficiency. Results revealed that organic carbon concentrations found in non-deposition areas were entirely controlled by the surface area of the mineral fraction. All or-

ganic concentrations fell within the suggested monolayer equivalent zone of 0.6 to 1 mg organic carbon·m^{-2} surface area. However, in depositional areas such as the Skagerrak up to 2 mg organic carbon·m^{-2} were found, indicating that here additional preservation mechanisms (*e.g.* deposition rate, bottom water O_2 concentration) must be responsible in controlling the sedimentary organic carbon content.

Nutrients in the Wadden Sea

This year we repeated the measuring of concentrations of phosphorus compounds in the Marsdiep tidal inlet around the phytoplankton spring-bloom (co-operation with G.C. Cadée, Department of Marine Ecology). Compounds measured were dissolved inorganic P (DIP), dissolved organic P (DOP), particulate inorganic P (PIP), particulate organic P (POP), iron-bound particulate P, calcium-bound particulate P, and P easily hydrolysable from organic matter (mainly algae). Additional parameters included SPM, POC, and particulate Fe, Mn and Ca. Apart from the strong decrease of DIP upon the start of the phytoplankton bloom, a compensating increase of DOP was observed shortly thereafter. Thus, the concentration of DIP + DOP remained approximately constant during the bloom at a level of ~1 µM. This demonstrates the importance of organic P sources for phytoplankton. The SPM in the Marsdiep is loaded with exclusively iron-bound phosphate, at a P:Fe ratio slightly below ratios measured previously in North Sea and Wadden Sea sediments. We conclude that desorption of PIP from particulate Fe-oxides may provide an additional P source during the spring bloom.

A strategy was developed and applied to estimate the natural background N and P concentrations in the Wadden Sea (co-operation with V.N. De Jonge, RIKZ). This strategy is based on the background concentrations previously estimated by RIKZ for the river Rhine and the coastal North Sea. Concentrations in the discharge from IJsselmeer into the Wadden Sea were estimated from hindcasted loads of the river IJssel and a retention model of the lake calibrated on data from the last 30 years. The calculations show that the nitrogen and phosphorus discharges of the IJsselmeer have decreased since the first half of the eighties, but that the loads are still 9 (N) and 6 (P) times larger than what may be expected for natural (unpolluted) conditions. Natural background concentrations of total phosphorus in the Wadden Sea were estimated at 0.5-1.0 µM, and of total nitrogen at 10-20 µM. At present, P and N concentrations are approximately 3-6 times higher.

Early diagenetic processes at European shelves and slopes

Within Ocean Margin Exchange (OMEX), an EC-MAST-funded programme, co-ordinated by R. Wollast (ULB, Belgium), we participate in the group Benthic Processes, a combined effort of GEOMAR (Kiel), NIOO-CEMO (Yerseke), Institut für Meeresforschung (Kiel), IFREMER (Brest) and the NIOZ Departments of Marine Chemistry and Geology, and Marine Ecology.

We participated in the cruise with RV 'Pelagia' from la Coruña to Texel (2 to 25 October). The principal aim of the study was to quantify fluxes of particles, including organic carbon, across the continental slope and to quantify organic carbon mineralization and burial rates. During this cruise activities were concentrated at the Iberian Margin, the Meriadzek Terrace and in the Goban Spur area.

In situ measurements of porewater oxygen concentration by use of the free-falling oxygen profiling lander TROL, shipboard pore water analysis of oxidants (O_2, NO_3^-, NO_2^-, SO_4^{2-}) and mineralization products (NH_4^+, Fe^{2+}, Mn^{2+}) were used to assess carbon mineralization rates. Burial rates are calculated from org. C content at depth in the cores and sediment accumulation rates (from ^{210}Pb profiles). The BOBO lander, deployed one year earlier, was recovered. Results on near-bed characteristics of current velocity, salinity, temperature, and nephelometry are at present analysed.

Monsoonal sedimentation in the Somali upwelling system

Particulate matter fluxes intercepted by moored sediment traps were analysed for their composition as a function of the monsoonal upwelling regime in a transect across the Somalia continental margin. Total mass fluxes show a distinct maximum during the SW-Monsoon in response to upwelling conditions (May-October), followed by a minimum during the NE-Monsoon when stratification prevails, and intermittent massive fluxes that result from lateral advection of fine resuspended sediment via intermediate nepheloid layers. These contrasts are also reflected by the mass flux and relative contribution of the main components, *i.e.* biogenic carbonate and silica, organic matter and a yet unspecified rest mass including other biogenic as well as lithogenic compounds. Some aspects will be discussed below.

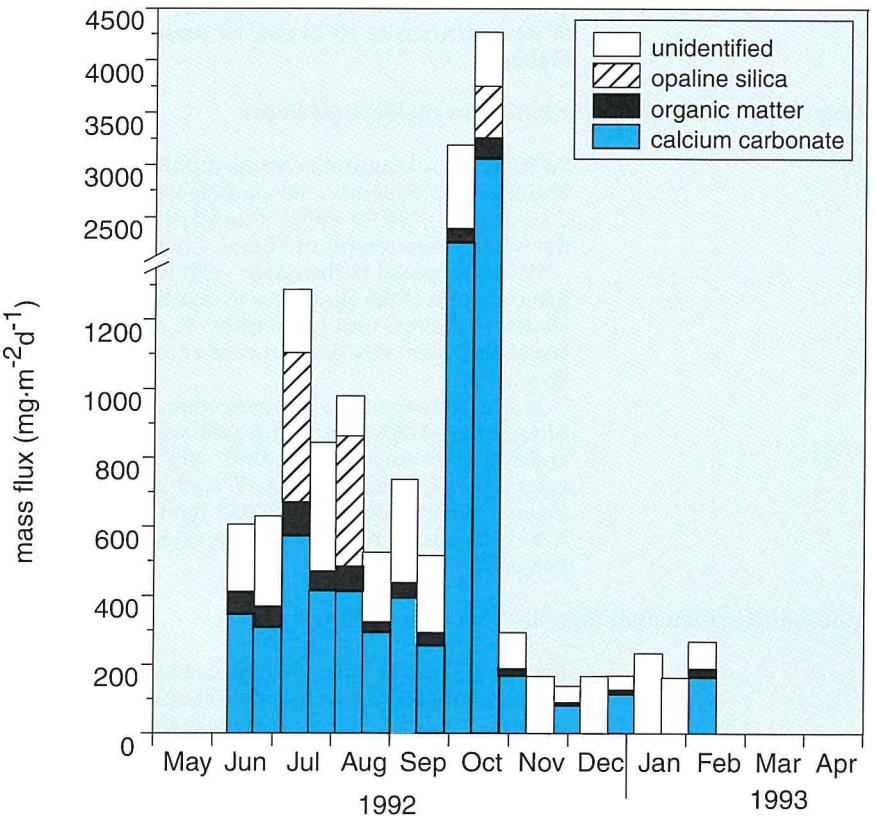
Biogenic silica seems to be the most labile component of the particulate flux to the sea floor. Dissolution is already apparent in the dissolved silica concentration of the collecting cups, which increase to saturation with age and the amount of available material. Pilot studies strongly suggest that typical 'upwelling' species of diatoms, which produce the massive fluxes of biogenic silica

during the SW-Monsoon, are preferentially dissolved and do not survive to sediment burial. What remains to form the sediment record of biogenic silica, are the larger, more heavily silicified species that contribute their skeletons during both monsoons. Core-top sediments indicate that over 90% of the arriving mass flux of biogenic silica is dissolved at the sediment-water interface, and even less survives early diagenesis judging from flux calculations based on sediment incubations (*in situ*) and pore water profiles.

The occurrences of up to 5% of marine benthic diatoms (allochthonous) in the traps and of up to 10% in the sediments imply some lateral transport, probably of resuspended material from the upper slope. No evidence was found for freshwater or eolian dust input (no freshwater diatoms or phytoliths), not from the traps nor from the sediments.

Analysis of stable nitrogen isotopes shows a strong upwelling imprint in the time-series, with $\delta^{15}N$ values down to 5‰ during the SW-Monsoon, and up to 9‰ during the low productive NE-Monsoon. This reflects the fractionation of 'upwelled' nitrate assimilated under non-nutrient limiting conditions as opposed to the intensive recycling of N-nutrients during stratification. However, no straightforward correlation is observed between the $\delta^{15}N$ and the mass flux of particulate nitrogen or other bioelements, with the possible exception of biogenic silica, a relationship which will be investigated in more detail in the near future.

Analysis of the dissolved phase of particulate components shows that several calculated mass fluxes, *e.g.* of biogenic silica, need to be corrected for dissolution, decomposition, leaching and other such processes occurring during deployment and storage, especially when the solid to solute ratio is low. Standard analytical methods, however, are hindered by the interference of additives introduced in the sample cups prior to deployment, *i.e.* $HgCl_2$ as a biocide and $Na_2B_4O_7$ as a pH-buffer. For instance, Hg leads to suppression of the DOC concentration as determined by high temperature catalytic combustion, but artificially enhances the ammonia concentration by spectrophotometric (phenol-hypochlorite) measurement. Other such interferences occur with respect to nitrate and strontium, whereas particular processing steps including filtration and freezing produce artefacts for instance for phosphate.



Particulate mass fluxes intercepted at 270 nm above the Somalia continental slope at a water depth of 1270 m. Massive fluxes in October are caused by sediment resuspension. High fluxes during the SW monsoon in summer are associated with coastal upwelling, whereas the low fluxes during the NE monsoon in winter reflect the stratified upper ocean conditions. Note the y-axis break; opaline (biogenic) silica has yet been measured in only 3 samples.

Cycles of silica and aluminum

—*Southern Ocean.* Profiles of interstitial dissolved Al and H_4SiO_4, obtained during Antares 1 were worked out in relation to Al/Si ratios in biogenic silica. Cores north and south of the Polar Front were compared. North of the Polar Front there was a pronounced maximum of dissolved Al at 1-2

cm depth in interstitial waters and a larger Al/Si ratio in biogenic silica than south of the Polar Front, where the content of biogenic silica was higher and no maximum of interstitial Al was found. South of the Polar Front there was a H_4SiO_4 excess in bottom waters, while north of the Polar Front there was no excess of H_4SiO_4, but an appreciable excess of dissolved Al in bottom water.

It is proposed that Al-silicates in sediments release dissolved Al, which is partly taken up by biogenic silica, decreasing its solubility and dissolution rate. It is concluded that terrigeneous Al-silicates act as a kind of filter, preserving part of the biogenic silica. In a zone around Antarctica where the ratio biogenic/terrigeneous silicates is high this mechanism does not work. (Co-operation with J.E.E. Van Beusekom. AWI, Bremerhaven).

—*Indian Ocean.* Nutrient concentrations in water samples were obtained on a German expedition in the NW Indian Ocean (Meteor leg 32/4, June 8 to July 9), part of the Indian Ocean JGOFS/WOCE programme. Part of the same area was covered during legs B and C of the Netherlands Indian Ocean Programme. It was a good opportunity to extend the data set, since during NIOP the data set obtained during the SW Monsoon was meagre due to bad weather.

H_4SiO_4 was determined manually on board, while phosphate, nitrate and nitrite were determined with auto-analyzers at NIOZ, after filtration and freezing on board. Also some H_4SiO_4 samples were analysed again with auto-analyzers.

Preliminary comparison with NIOP and Geosecs data in the same area shows that, with few exceptions, this procedure gives reliable results for nitrate, nitrite and phosphate. For H_4SiO_4 below about 50 µM, freezing has little effect, but above about 70 µM, frezing decreases the concentrations by 4-8%.

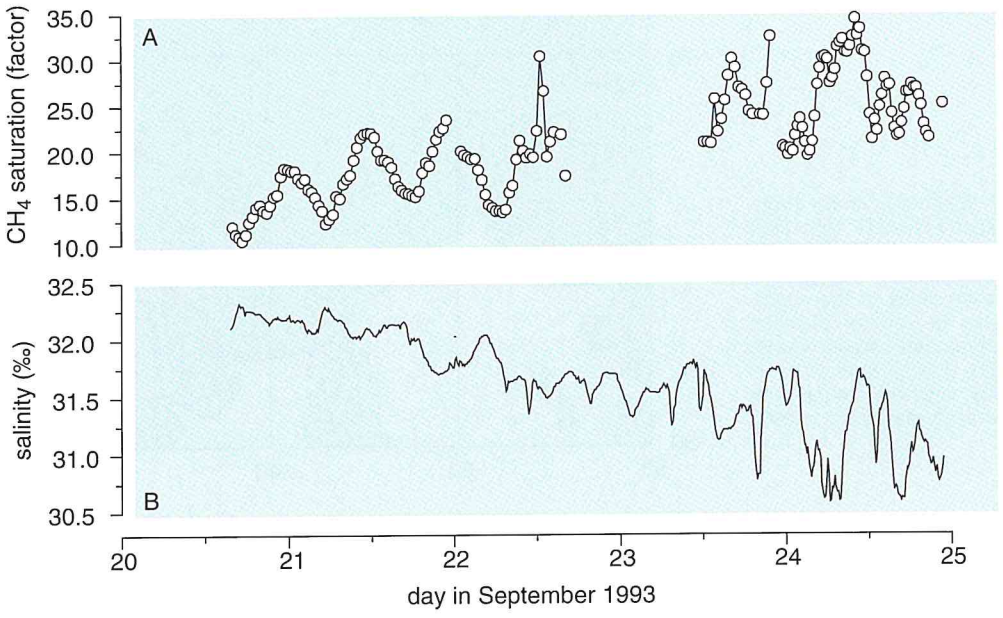
Water-atmosphere exchange of N_2O and CH_4 in marine systems

This project aims to study the influence of the marine environment on atmospheric concentrations of N_2O (nitrous oxide) and CH_4 (methane) in the marine environment. Research was focused on the Scheldt river and estuary, the Dutch coastal waters, the North Sea, and the northwest Indian Ocean. Surface water concentrations of N_2O and CH_4, resulting emissions into the atmosphere, and underlying microbial processes varied enormously over these contrasting environments in response to the availability of oxygen and substrates.

In the coastal zone, concentrations of N_2O and CH_4 increase drastically along the aquatic continuum from sea to land, because carbon and nitrogen loadings and resulting microbial turnover rates are high. In contrast, production of N_2O and CH_4 in the open North Sea is low, as these waters are well oxygenated and rather oligotrophic. North Sea gas exchange is largely driven by seasonal warming and cooling, whereas the net annual exchange is small.

N_2O production rates in the open waters of the Indian Ocean are low. However, long residence times allow N_2O accumulation in deep water. Wind-driven upwelling of this deep N_2O-rich water results in extremely high N_2O emissions to the atmosphere. In the Arabian Sea, both N_2O production and consumption are distributed along the oxygen gradient, resulting in substantial net N_2O emissions. Similarly, subsurface CH_4 production induces significant CH_4 emissions.

It is concluded that a relatively large proportion of the global marine N_2O and CH_4 emissions originates from the coastal zone, upwelling areas, and oxygen poor waters.



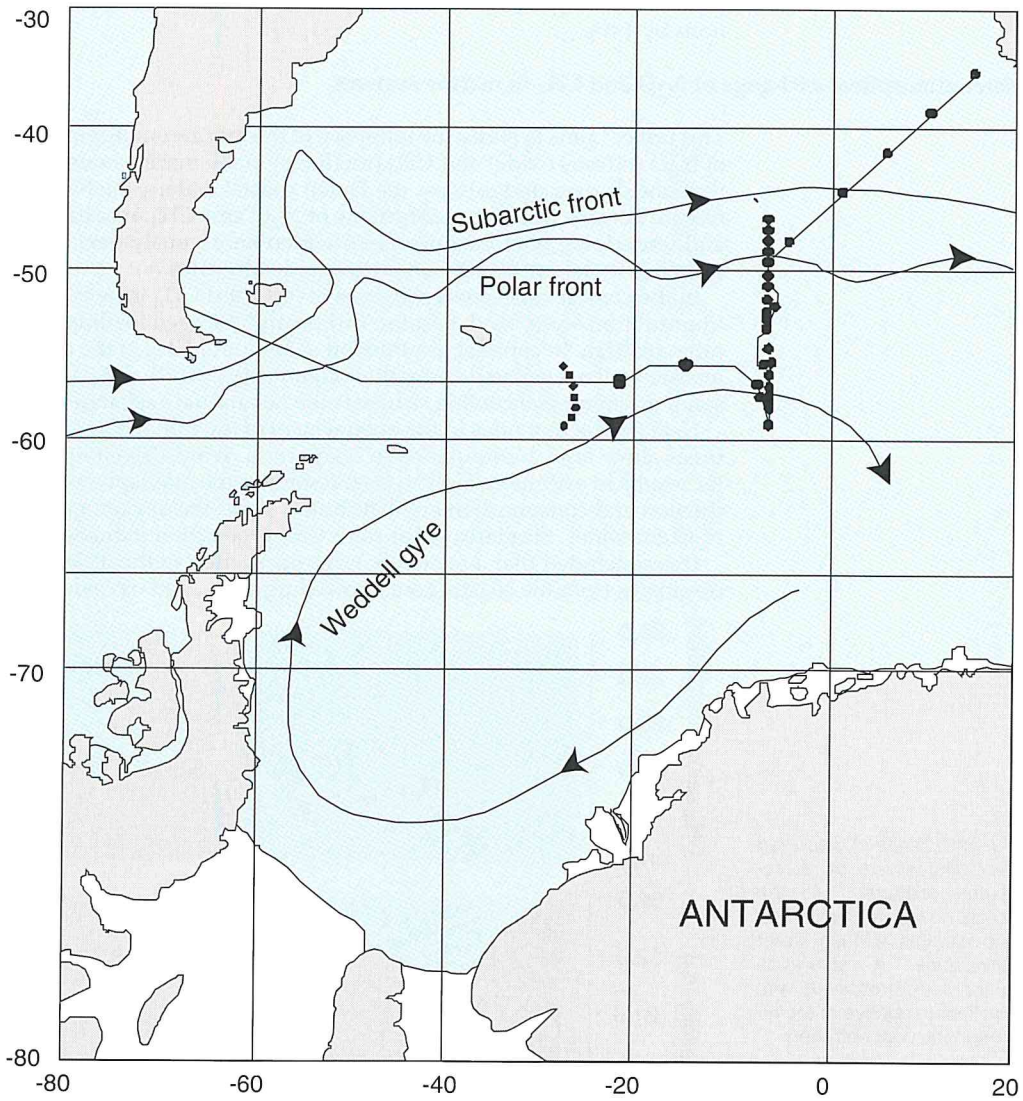
(A) Time series of dissolved CH_4, measured at a research platform off the Dutch coast, showing high and variable surface water saturations. A saturation factor of 1 corresponds with equilibrium relative to the atmospheric concentration.

(B) Salinity is negatively correlated with CH_4, suggesting that freshwater discharge by rivers is an important source of coastal CH_4.

Contributors: *W. Van Raaphorst* (early diagenesis and SPM), *J.F.P. Malschaert* (early diagenesis, chemical analysis, data analysis), *J.C. Smit* (data analysis SPM), *W. Helder* (biogeochemistry), *L. Lohse* (early diagenesis, N-cycling), *H. De Hey* (carbon cycling North Sea), *Tj.C.E. Van Weering* (sedimentation processes), *W. Boer* (SPM and ^{210}Pb analysis), *A.J. Van Bennekom* (Si-cycling, hydrography), *E. Okkels* (sediment analysis), *A. Vaars* (core scanning and instrumentation), *R. Gieles* (sediment analysis), *H.P.J. De Wilde* (nitrousoxide and methane), *C.P. Slomp* (phosphorus cycling), *G.J.A. Brummer* (sediment traps and biogenic Si), *J. Van Iperen* (diatoms), *H.T. Kloosterhuis* (C/N analysis and SIMS), *J.C. Van Ooijen*, *K.M.J. Bakker* and *A. Van Koutrik* (nutrient analysis), *H.C. De Stigter* (sedimentology and foraminifera).

2. CARBON AND TRACE METALS IN THE PELAGIC MARINE ECOSYSTEM

The ecology of plankton strongly depends on the inorganic and organic forms of carbon and trace metals in the water column, but also governs the occurrence and inventories of the chemical entities. Similarly, the research is strongly intertwined with the Department of Biological Oceanography in such a way that the graduate students and other investigators take full advantage of the expertise in both departments. In early 1995 the group published evidence that iron availability through plankton dynamics leads to major utilization and atmospheric drawdown of carbon dioxide.



RV 'Polarstern' cruise 'Frühling im Eis' (ANT X-6, 1992) and stations in the Southern Ocean (line with dots) , used for the study of the importance of iron for plankton blooms and carbon dioxide draw down. Lines with arrows indicate frontal and current systems in the area.

The 1995 field work in IGBP-JGOFS context continued this multidisciplinary approach with focus on the Antarctic Ocean in the context of the national Antarctic research and national climate research programmes and facilitated the existing long-term collaboration agreement between NIOZ

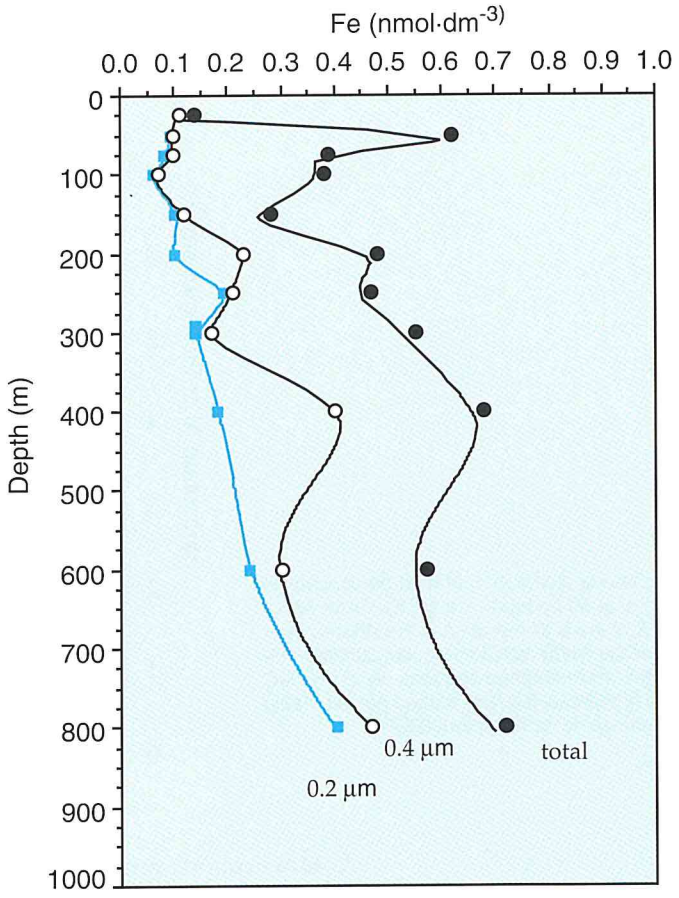
and AWI. In March-May ten scientists of both departments studied the iron-zinc-plankton-carbon dioxide interactions in the Pacific sector of the Antarctic Ocean. In December 1995 / January 1996 four chemists studied iron and the CO_2 system in context of a Southern Ocean JGOFS plankton ecology expedition to the Weddell Sea led by prof. V. Smetacek (AWI, Bremerhaven). In July and August during two US JGOFS Indian Ocean cruises each time two scientists of both NIOZ departments studied several aspects of organic carbon and plankton dynamics.

Trace Metals in the Oceans

—*Distribution and speciation of iron in the Pacific sector of the Antarctic Ocean.* During cruise ANT XII/4 (21 March to 14 May) in the Pacific sector of the Antarctic Ocean on board of RV 'Polarstern' field samples for trace metals Fe, Cd, Cu, Ni, Zn, Pb, Co and iron speciation research were collected at 10 stations along a north-south transect at 89°W crossing the Subantarctic Front and Polar Front areas, the Antarctic Circumpolar Current (ACC) and closer to the continent, the Bellingshausen Sea. In a transportable clean air laboratory the samples from standard depths of 25, 50, 75, 100, 150, 200, 300, 400, 600 and 800 m were submitted to a size fractionation with subsampling of each GoFlo sampler for unfiltered, 0.4 µm filtered and 0.2 µm filtered water.

For the first time it was possible to measure iron on shipboard using the following newly implemented techniques:

A: Adsorptive Cathodic Stripping Voltammetry (ACSV), measuring reactive dissolved iron concentrations and, by competitive ligand equilibration, organic natural ligand concentrations. Preliminary results showed that reactive iron concentrations were below 1 nM in the whole area. In the ACC reactive iron concentrations were constant with depth and around 0.15 nM. This in contrast to those in the Bellingshausen Sea, close to the continental margin, where concentrations range from 0.25 to 0.75 nM, increasing with depth. Here the iron profiles show some patchiness. Around the Polar Front, surface concentrations were 0.4 nM decreasing with depth to constant values of 0.20 nM. Competitive ligand titrations showed that the amount of iron-binding ligands is sufficient to complex 90% or more of the available iron. The log K'FeL, the conditional stability constant for organic ligands complexing iron, was calculated to be between 21 and 22. This value is equal to those found recently in surface waters of other oceans and indicates that iron binding complexes are very strong. Calculated organic ligands concentrations are in the order of 5-13 nM well above the apparent iron concentration and ensuring full complexation.



Vertical profiles of dissolved (filtered <0.2 µm and <0.4 µm) and total dissolvable (unfiltered) iron at 58°S, 92°W in the Antarctic Ocean.

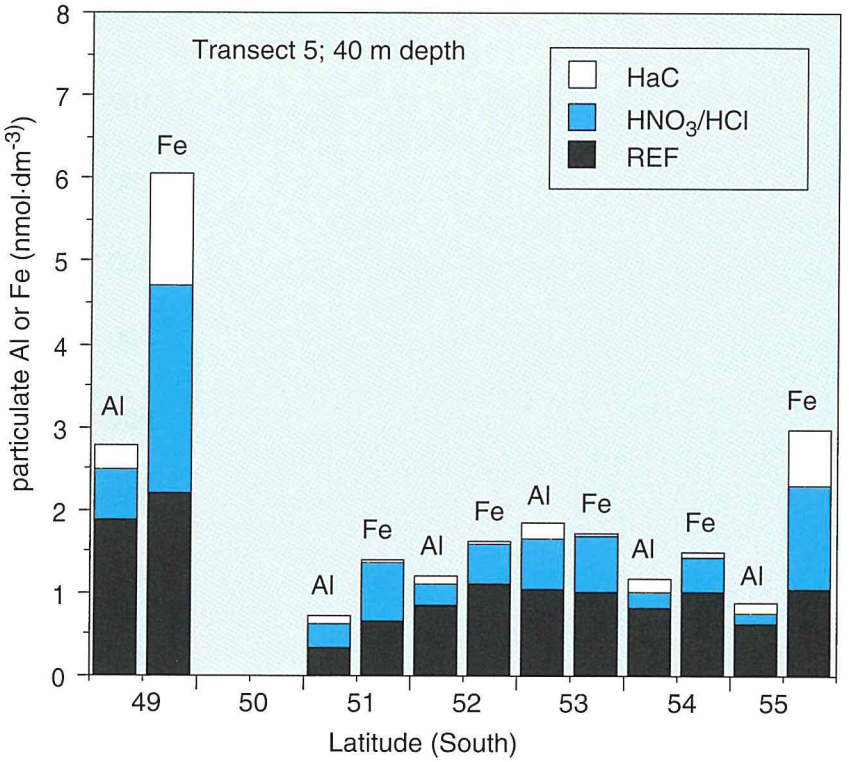
B: Flow injection analysis using in-line preconcentration on a chelating resin column followed by chemoluminescence detection (FIA-CL), measuring total dissolved iron in acidified samples. Accuracy and reproducibility were confirmed using NASS-4 reference seawater, while a detection limit of 0.015 nM was achieved.

Along the transect 52°S - 69°S dissolved iron showed a dynamic distribution consistent with the hydrography of the area. The very low concentrations ranged from 0.05 nM near the surface to 0.4 nM in deeper waters, typical for remote waters far from land masses. Somewhat enhanced concentrations were found in the Polar Front as well as near the continental margin, whereas in between the ACC had depleted iron concentrations. This is consistent with the very low abundance of phytoplankton (Chl *a*) in the region and the conspicuous absence of plankton blooms. It appears that the biological productivity is severely suppressed due to iron deficiency.

—*Distribution of metals in the Atlantic sector of the Antarctic Ocean.* Along sections at 6°W sampled in 1992, the concentrations of dissolved Fe were on average low (~0.3 - 0.5 nM at 40-300 m depth) as reported earlier. In the more rapidly eastward flowing Polar Front waters the average concentrations of dissolved Fe were 1.87 nM (transect 5) decreasing with ongoing spring season to 1.14 nM (transect 11). In the energetic Antarctic Ocean the Polar Front stands out as a most dynamic feature capable of stirring up bottom sediments when flowing over or alongside the South American shelves. At the 6°W section some 2000 km downstream of the South Georgia plateau the shelf input of dissolved and particulate Fe, particulate Al, Mn and Cu was still well discernible.

The particulate distribution of trace metals along the sections at 6°W was determined in three fractions each (easily dissolvable, reactive and refractory). For particulate Fe the total amount showed a distinct maximum at the Polar Front, as well as at the Marginal Ice Zone (MIZ) situated at the Weddell Gyre front. Similarly distinct maxima of total particulate Al were observed at the Polar Front as well as at the retreating Marginal Ice Zone (MIZ) where particles arrived from the melting ice. The total particulate Al concentrations in the area of the Polar Front and the MIZ were of the same order in both transects, which means that the magnitude of particle import at a given station in both transects remains fairly uniform over time. The high Fe and Cu concentration in the Polar Front clearly indicate terrestrial input in this area. High Cu is indicative for a diagenic sediment source.

The leachable fraction of Fe and Mn (which is conceivably more easily available for biota) at the Polar Front and the southern ACC front represents about two times more of the total particulate metal, as compared to the particles in the intermediate Southern ACCs waters. The leachable fraction of Cu in the Polar Front or the MIZ is not more than in the area in between, because Cu forms no such reactive oxyhydroxides as Fe and Mn, which were dissolved in the first digestion step.



The lateral distribution of total particulate Fe and Al at 50 m depth at a section from 48° to 56°S at the 6°W meridian in the Atlantic sector of the Antarctic Circumpolar Current. The metals were leached sequentially in (1) HaC and (2) HNO_3/HCl. The portion not leachable is referred to as refractory (REF).

At 40 m depth at transect 5 the calculated molar Fe/Al ratio for total material was between 0.32 and 0.56. At 200 m depth at transect 5, in between the fronts, the calculated molar Fe/Al ratio for

total material was about 0.48-0.71, and only about 0.25-0.52 for the refractory Fe *versus* Al, the latter range close to the global average of 0.33 for continental input. However, at the fronts the total ratio attains values of 2.56 in the southern ACC front and 1.63 in the Polar Front, whereas the refractory Fe *versus* total Al yields ratios of about 1.47 and 0.83, respectively. In this respect the assumed molar crustal abundance ratio of 0.33 is considered a minimum average value for marine particles, as marine biogenic Fe fractions and marine authogenic Fe-oxide coatings would not be included. For example, a molar ratio Fe/Al = 0.76 has been found by earlier authors in the Weddell Sea.

—*North Sea.* Results of trace metal data obtained during the 'Bloom' expedition in 1993 were worked out. In general, no differences were found in trace-metal concentrations in and outside the phytoplankton bloom. Concentrations for cadmium and nickel were low and rather constant with depth, 48 ± 39 pM and 108 ± 45 pM, respectively. Increased surface concentrations for copper, zinc and lead were observed in the Norwegian Trench, in less saline water coming from the Baltic Sea and the German Bight. Excluding those higher surface values, the mean zinc and nickel concentrations in the upper 100 m of the water column were 4.5 ± 1.6 nM and 3.66 ± 1.36 nM. Copper was the only element that showed enriched surface values at most stations. The mean copper surface concentration was 1.8 ± 0.65 nM, but 1.61 ± 0.4 nM, for sub-surface water. The small variations and concentration levels found belong to the lowest ever reported for these trace metals in northern North Sea waters.

—*Indian Ocean.* The horizontal and vertical distribution of trace- and major elements in sediments of the northern Indian Ocean and the processes to which these elements are subjected were studied. It was shown that sediments in the upwelling area of the northern Indian Ocean are different in element concentrations compared to those more offshore, which means that the upwelling zone has a great impact on the underlying sediment. The huge amount of organic material supplied to the sediment during the upwelling period causes a depletion of oxygen and other electron acceptors. This results in low Mn, Fe and other trace metal concentrations, both in the solid phase and in the dissolved phase. Also, newly supplied organic matter cannot be mineralized completely, as indicated by the high organic carbon content. Kd values calculated for each trace element decreased with increasing bottom depth, except for Mn. Despite this and due to the lack of freshly supplied Mn by for instance rivers, the actual Mn concentration in the sediments as well as in the pore water was rather low for reducing sediments.

The solid phase concentrations of Si, Al and Fe were rather constant and did not show much variation with bottom depth. Calcium carbonate concentrations were low at stations where the bottom depth was > 5000 m and situated beneath the $CaCO_3$ compensation depth. The mean concentration of Mn, Cu, Zn, Ni and Pb in the upper 2 cm of the sediment increased with increasing bottom depth. For Mn this increase was one order of magnitude. This increase can be explained by several possibilities: difference in grain size, atmospheric transport and lateral transport of element enriched particles. Cd and Cr showed an opposite behaviour, a decrease with increasing bottom depth.

The vertical depth profiles of dissolved trace metals showed rather smooth profiles with low concentrations in the upwelling area and rather patchy profiles with higher concentrations at the deepest stations (near the Equator). Generally, the supply of high amounts of organic carbon to sediments in the upwelling zone creates a reducing environment which results in net transport of metals from the shelf to the deep sea.

—*The role of iron and other trace elements in oceanic ecosystems.* During the ANT XII/4 expedition with RV 'Polarstern' to the Bellingshausen Sea, an important milestone was reached: for the first time it was possible to combine bottle iron enrichment experiments with on-line iron measurements. Iron enrichment experiments were performed with on-line iron measurements using flow injection analysis followed by chemoluminescence, iron complexation measurements using adsorptive cathodic stripping voltammetry, on-line flowcytometry and nutrient analyses. In total, eight series of iron enrichment experiments were performed with a total of 64 experimental treatments.

The conditions met during the cruise were excellent. High nutrient concentrations were accompanied by low chlorophyll *a* concentrations. The low iron concentrations encourage speculation on a decisive role of iron in the limitation of build-up of phytoplankton. Preliminary results suggest that, indeed, iron additions did have a significant effect on the physiology of the phytoplankton. The phytoplankton community was dominated by small species. Addition of iron has, depending on the parameter investigated, larger, smaller or no apparent effects. The overall parameters such as cell number, chlorophyll *a* and removal of macronutrients from the seawater showed little or no response after iron addition. In contrast, effects on physiological processes such as the nitrogen metabolism were explicit: clear effects on N-uptake and nitrate reductase were observed. Furthermore, the presence of flavodoxin, the non-iron analogue of the iron-containing ferredoxin, was demonstrated using Western blotting, which can be seen as an extra molecular indicator of iron stress. The use of physiological and molecular indices of nutrient stress

in phytoplankton was further pursued in the laboratory and during a working visit to Brookhaven National Laboratory (USA).

In addition to the effects of iron, other trace elements were taken into consideration. Emphasis was on the effects of zinc and cobalt on the inorganic carbon uptake. A method for measurement of carbonic anhydrase was brought into practice and combined with pCO_2 measurements in the water. On board RV 'Polarstern' during ANT XII/4, carbonic anhydrase measurements together with pCO_2 measurements were performed. Some stimulatory effect of Zn and Co addition on carbonic anhydrase was observed, but the difference between controls and addition was relatively small.

Biogeochemistry of *Phaeocystis* colonies

The colonial matrix of *Phaeocystis sp.* (Haptophyceae) constitutes a particular microenvironment in which the chemical conditions are driven by photosynthetic rate of colony cells. In the frame of the EC project on the 'Biogeochemistry of *Phaeocystis* colonies and their derived aggregates' in collaboration with Dr. C. Lancelot (ULB, Brussels) and Dr. U. Riebesell (AWI, Bremerhaven), the biological and chemical mechanisms controlling precipitation of Mn oxyhydroxides inside *Phaeocystis* colonies were investigated. Experiments were carried on both cultured colonies and on samples collected in the continental coastal waters of the North Sea during a cruise on RV 'Belgica' in May 1995, making use of a combination of radionuclides (^{14}C, ^{54}Mn) and biological inhibition and cleaning techniques (Ti-wash technique). This allows us to distinguish between mechanisms of passive adsorption, physiological uptake by the cells and precipitation and adsorption within the colonies which are due to the photosynthetic activity of the colonial cells. Results show that the particulate Mn accumulation regulated by the colonial cells photosynthesis can represent as much as 70% of the total dissolved ^{54}Mn transfer to the *Phaeocystis* colonies. This accumulation depends on the light history of the colonies and on their physiological state. It is concluded that this biogeochemical process could let *Phaeocystis* play a significant role in the cycling of trace metal but also in structuring the phytoplankton community and hence the associated food web in Mn-limited marine systems.

Carbon dynamics in the upper ocean

—*Hydrography and air-sea exchange of carbon dioxide in the Dutch coastal zone.* The hydrography and inorganic carbon characteristics in surface waters which were detected at Measuring Platform Noordwijk in September 1993, were analysed. The hydrography at the platform was influenced by variations in tidal and wind mixing strength, freshwater outflow, and seasonal cooling. Surface water CO_2 characteristics were additionally affected by biological processes.

—*CO_2-system in the Antarctic Ocean.* For this joint research project with Dr. Fahrbach and Dr. Hoppema (AWI, Bremerhaven), two cruises were undertaken with support from the NWO Global Change program. During cruise ANT XII/4 (21 March to 14 May) in the Pacific sector of the Antarctic Ocean, Total CO_2 and pCO_2 in samples drawn from the underway pumping system as well as from conventional water bottles were determined. The second expedition went through the frontal system into the Weddell Sea region to pursue the same sets of measurements. The objective is to understand anticipated co-variances with chlorophyll and iron abundance as function of the underlying physical mixing of frontal dynamics.

—*CO_2 limitation and calcification of E. huxleyi. Emiliania huxleyi* fixes inorganic carbon into organic carbon as cell material as well as into inorganic carbon as calcite platelets or coccoliths. These processes affect the fugacity (~partial pressure) of carbon dioxide in opposite ways. For *E. huxleyi* the formation of coccoliths thus provides a means to generate its own carbon dioxide for organic matter growth:

$$2\,HCO_3^- + Ca^{2+} = CaCO_3 + CO_2 + H_2O$$
$$CO_2 + H_2O + \text{photons energy} = (CH_2O)\text{organic} + O_2$$

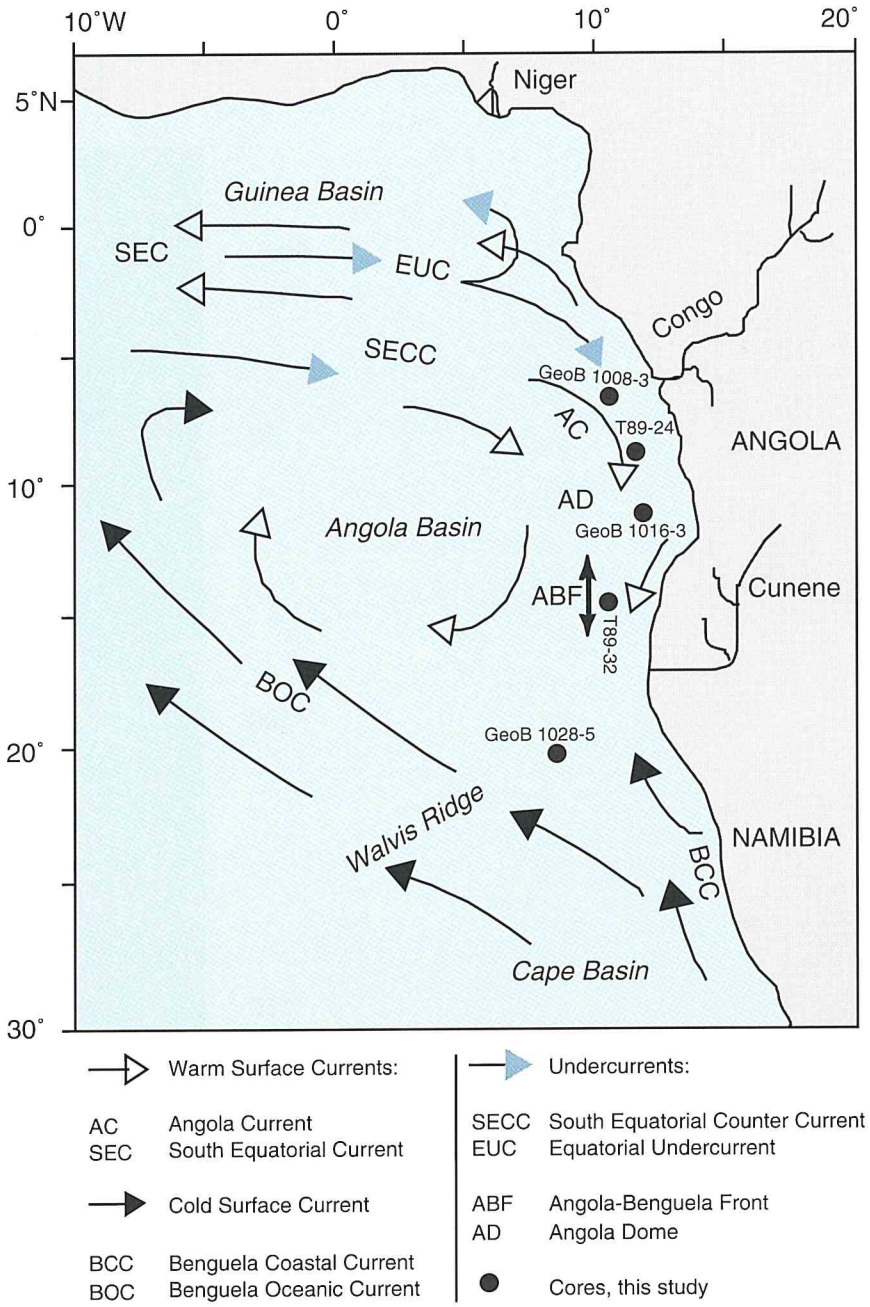
Three factors influence the availability of carbon dioxide to *E. huxleyi* in nature. Firstly, the occurrence of *E. huxleyi* blooms after diatom blooms in spring when some CO_2 has already been utilized. Secondly, the enhancement by *E. huxleyi* itself of carbon export out of the photic zone through co-sedimentation of organic and inorganic carbon. And lastly, the increase of carbon dioxide in the air through burning of fossil fuels. Because of its cosmopolitan distribution and its bidirectional involvement in the biological carbon pump the response of *E. huxleyi* to low and high ambient concentrations of carbon dioxide is under investigation.

Contributors: *H.J.W. De Baar* (chemistry), *D.C.E. Bakker* (CO_2), *E. Buitenhuis* (CO_2/biota), *E. De Jong* (CO_2), *J.T.F. De Jong* (metals), *F.A. Koning* (CO_2), *M.A. Van Leeuwe* (metals/biota), *A.A.J. Majoor* (CO_2), *R.F. Nolting* (metals), *J. Van Ooyen* (nutrients), *J. Rommets* (CO_2), *V. Schoumann* (metal/biota), *K.R. Timmermans* (metals/biota), *C.J. Wiebinga* (bacteria/organics).

3. PALAEOCEANOGRAPHY

Palaeoceanography is a science that investigates oceanographic processes, their causal relations, and their changes through time. Reconstruction of old oceans is one of the tools. The information is stored in the marine sediments as resistant physical, chemical and biological signals. For this reason, palaeoceanography does not confine itself to studies of the sediment and its components, but also focuses on the way in which the present ocean produces the resistant signals, and the change of the signals before they are eventually stored in the sea-floor sediments. Besides pure oceanic signals, the sediments may also contain signals of the climate on land. Such signals allow us to correlate the continental with the oceanic climatic changes and provide a unique tool to study their causal relations.

An extensive project in the SE Atlantic Ocean focuses on the late Quaternary palaeoceanography in relation to the palaeoclimate of equatorial Africa. The objective of a second project is the monsoon system of the NW Indian Ocean. The Indonesian basins are the theme of a third palaeoceanographic study. The study of the geochemical cycles of Si and Al is an example of a project which is primarily directed towards the actual behaviour of biogenic silica in the water column and its early diagenetic fate in the surface sediment.

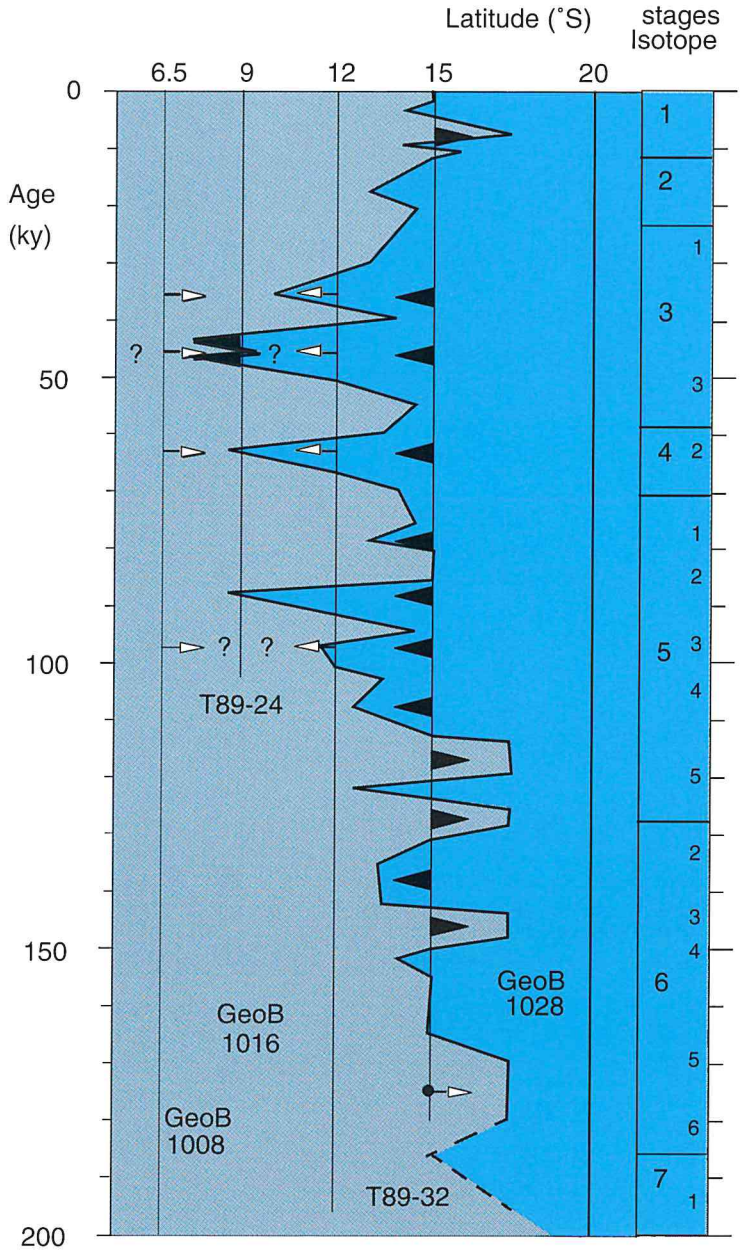


Generalized surface and shallow subsurface circulation in the southeastern Atlantic Ocean off Africa and locations of the cores.

Palaeoceanography of the Angola Basin and the terrestrial climate

—*Movements of the Benguela Current system and advection in the equatorial oceans.* The astronomical 'Milankovic' cycles of precession, obliquity and eccentricity control the seasonal and latitudinal distribution of insolation. It is widely believed now that these cycles drive the major climate cycles externally or set the phase of oscillations that are driven internally. Since each of the external processes or internal responses operates at a characteristic rate, the mechanisms of climatic change are strongly frequency-dependent. A geologist who wants to explain the climatic record he observes should therefore use some form of analysis in which the total historic narrative is parcelled out among different frequency bands.

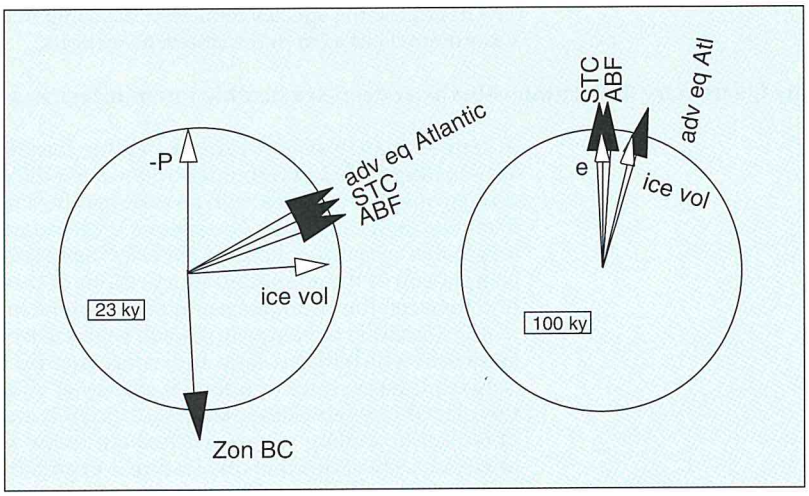
Between the warm south-flowing Angola Current, the easternmost limb of the South Equatorial Counter Current, and the north-flowing cold water of the Benguela Current there is a convergence region called the Angola Benguela frontal zone (ABF). We reconstructed positions of the ABF for the last 180 000 years with the use of planktic foraminifera (NIOZ) and palaeo sea-surface temperatures from four cores of the Angola-Zaire margin (based on temperature-sensitive organic molecules measured in Bremen). Strong northward shifts occurred in the 'glacial' stages 4 and 3.3-3.1, but not in the stages 6 and 2. The southernmost positions, not far from the present one, were occupied in the 'interglacial' stages 5.5 and 1, but also in 'glacial' stage 6.3. The shifts are also visible in a 500-ky-long foraminifera record from the Cape Basin.



Reconstruction of the average positions of the Angola-Benguela Front over the last 180 ky. The arrows indicate the positions of the ABF with respect to the locations of the cores, based on the foraminifera contents and the temperature sensitive organic molecules. For locations of the cores see previous figure.

Spectral analyses of the ABF record reveal significant variance in the 23-ky (precession) and 100-ky (eccentricity) orbital frequency bands. In the precessional band, the system also performs swings between more zonal and more meridional directions of the Benguela Oceanic Current. The shifts precede the swings by 6 600 y. The extremely northern position of the ABF in stages 3 and 4, 60-40 ky BP, is driven by the 100-ky (eccentricity) component. There are only weak 41-ky (obliquity) movements.

The 23-ky and 100-ky shifts of the ABF are in phase with the global ice volume, the meridional movements of the Subtropical Convergence zone (STC) in the Southern Ocean, and with cool advection variations in the equatorial Atlantic . This indicates that the movements are probably driven by meridional displacements of the belt of westerly winds over the southern hemisphere.



23-ky (precision) and 100-ky (eccentricity) phase clocks of the movements of the Angola Benguela Front and related features. Zero positions of the phase clocks are defined at minimum precision index (-P) indicating maximum boreal summer insolation (on 21 June) and maximum eccentricity (e).

The arrows indicate the phases of the 'warmest' expressions of the features: ABF=Angola-Benguela Front, and STC=Subtropical Convergence in the Southern Ocean, both in southernmost position; adv eq atl = minimum cold advection in the equatorial Atlantic, ice vol = minimum global ice volume. Further: Zon BC = Naximum zonality Benguela Current.

The northernmost positions of the ABF coincide with strong sea-surface temperature minima in the Arabian Sea and the equatorial Pacific Ocean. Like in the equatorial Atlantic, these temperature minima are probably the result of increased advection of surface water from the south that is also caused by the northward eccentricity-driven movement of the westerlies and the associated oceanic polar fronts.

Due to the near-absence of the 41-ky cycle in the equatorial phenomena, the northernmost position of the ABF and the strongest equatorial advection occurred 60-40 ky BP (Early Weichselian), and not during the Saalian (190-130 ky) and the Last Glacial Maximum (18 ky BP). Extremely southern positions occurred during the Eemian (125-120 ky BP) and Holocene, but also twice during the Saalian. So, the Last Glacial Maximum is not a representative example of ice-age related features in low-latitude regions.

—*Long-term changes in surface circulation.* Core T89-40, Walvis Ridge, SE Atlantic, reveals a planktonic foraminiferal record of 1.1 Ma. The surface water circulation of the Southeast Atlantic is dominated by wind driven systems: the Benguela Current, the coastal upwelling system and the subtropical gyre. Furthermore leakage from the Indian Ocean as well as the position of the Subtropical Convergence (STC) has a strong impact on the system. The purpose of this study is to establish a long-term record of the variations in the surface circulation of the SE Atlantic and to study its causes.

Based on the frequency patterns, three sections can be recognized in core T89-40. A major change occurs at the isotopic stage boundary 12 to 11 (423 ky BP). A second boundary is noticed at the isotopic stage boundary 22 to 21, *c.* 870 ky ago. The downcore distribution of groups derived from an overall cluster analysis does not yield a clear subdivision of core T89-40. To see whether the different sections reflect environmental changes cluster analysis was carried out to the 3 sections separately.

The groups in the upper section represent the 4 main hydrographical features: the subtropical gyre, the eastern edge of the gyre influenced by westward excursions of the coastal upwelling system, the coastal upwelling system itself and a group of southern origin. An expatriate within the subtropical gyre group, the left coiled *N. pachyderma*, is related to very nutrient-rich waters of the southern Benguela coastal upwelling region entrained by passing Agulhas rings. The glacial periods are marked by an increase in productivity due to enhanced coastal upwelling.

In the middle section, the composition and distribution of 3 groups (subtropical gyre, gyre edge and south) reflect a colder climate compared to the upper section, especially in the upper half of the middle section (isotopic stage mid 15 - stage 12). All major representatives of classic southern, polar influences are placed together in one group, and species related to coastal upwelling have increased in abundance. During stage 12, an equatorward shift of the STC of 7° has been recorded.

A shift of this magnitude would close the passage of warm, salty Indian Ocean waters into the South Atlantic and strongly alter the thermohaline circulation of the oceans.

The lower section reflects an amelioration of the climate compared to the middle section. The subtropical-gyre group is split into a more tropical and a more subtropical group. A group of southern influences is absent. Some of these southern species, left coiled *N. pachyderma* and *G. quinqueloba*, are aligned to the tropical group and might reflect similar hydrographical features as left coiled *N. pachyderma* in the upper section. The gyre-edge group includes species pointing to the cool season and activity of filaments induced by coastal upwelling.

Summarizing, the faunal groups based on cluster analyses of the 3 sections separately reflect major environmental changes during the Quaternary. The classic rule 'the present is the key to the past' is expressed by the single species and not by groups derived from an overall cluster analysis. The habitat of the species remained the same in time, and therefore yields information on the environmental changes in the different sections.

Late Quaternary fluctuation patterns of deep-sea benthic foraminifera as a reaction on surface water productivity

A statistical analysis of deep-sea benthic foraminifera species from a piston core (T89-40) from Walvis Ridge (3073 m water depth) revealed different groups of benthic foraminifera species. One group consists of species with an endobenthic lifestyle that require relatively high fluxes of organic matter to the sea floor. The species with a statistical significance of ≥ 5% in this group are: *Globobulimina subglobosa, Pullenia bulloides, Sphaeroidina bulloides, Uvigerina auberiana, U. peregrina*. A comparison of the abundance fluctuations of this group with oxygen-isotope data shows the relation between the abundance and the different climatic periods in the late Quaternary.

An estimation of palaeofluxes will be made by means of relative abundance of several indicator species of which the ecology and, consequently, trophic requirements are well known.

Accumulation rates of infaunal species of benthic foraminifera show extremely high values in the 'glacial' oxygen-isotope stages 6.2, 8.2, 8.4, and 8.6, which may be due to the fact that a 'branch' of coastal upwelling waters reached out to the site in times of very low temperatures. There are, however, indications that this feature is caused by climatic shifts rather than enhanced upwelling.

The terrestrial climate

Based on the clay-mineral distribution in sea-surface samples from the Angola Basin, we distinguish the following terrigenous sources: the drainage area of the Zaire (Congo) River and, possibly, the Kunene River, and the Namibian desert and Kalahari savannah in southern Africa. The latter minerals are probably supplied by the SE trade winds. The different origins are recognized in the clay mineral contents of core T89-32 taken from below the present Angola-Benguela Front. So the kaolinite peaks in the X-ray diffractograms of the core samples vary in shape, and these variations point to variations in the dust supply by the SE trade winds. Preliminary results of spectral analyses of kaolinite form factor show a dominant variance in the 41-ky (obliquity) orbital frequency band. This suggests that the aridity in southern Africa depends on variations in the strength of the westerly winds rather than meridional movements of the climate zones in the southern hemisphere.

The project receives benefit from Dr. R. Schneider and Dr. G. Wefer from the Department of Geosciences, Bremen University, who provided us with the $\delta^{18}O$ measurements of the studied cores.

Contributors: *J.H.F. Jansen* (palaeoceanography), *L. Ben Khelifa* (continental diatoms), *A.J. Van Bennekom* (silica cycle), *S.J. Van der Gaast* (X-ray diffraction), *H. Gipp* (benthic foraminifera), *E. Ufkes* (planktic foraminifera), *G.J.M Versteegh* (biomarkers), *A.J. Vaars* (XRF core scanner).

4. SEDIMENTATION AND SEDIMENT TRANSPORT

Shelf sedimentation

In the framework of the VvA 4 project, a cruise was undertaken to the central and northern North Sea (29 May to 4 June) to collect additional box- and pistoncore samples along a transect from the Shetland Islands to Den Helder.

The ^{210}Pb-derived sedimentation and accumulation rates for Skagerrak and Norwegian Channel indicate an annual accumulation in these major North Sea basins of 74×10^6 tons per year, of which the amount of organic carbon is 1.0×10^6 tons per year. These values cannot be explained other than by assuming considerable seabed erosion and sediment reworking in the shallower southern North Sea, and indicates that finally over 90% of the amount of preserved organic carbon produced in the North Sea accumulates in the NE North Sea basins.

Particulate water samples for $^{239+240}Pu$ and ^{238}Pu measurements were taken in the North Sea in April and October. First results from April show $^{239+240}Pu$ concentrations of 0.005 $mBq \cdot kg^{-1}$, which just exceeds the detection limit for 100 dm^3 samples. Samples taken in October 1995 are tenfold in size.

Sources of Pu in North Sea water are Sellafield (UK) and Cap la Hague (F), and to a lesser extent resuspended sediments. Top layers of sediments have concentrations of $^{239+240}Pu$ which exceed the detection limit of 1 mg $Bq \cdot kg^{-1}$ by up to 0.6 $Bq \cdot kg^{-1}$.

Atmospheric samples of 10 dm^3 were too small to detect any plutonium, *i.e.* the concentration was below 0.02 $mBq \cdot dm^{-3}$.

The flux of atmospheric ^{210}Pb is sampled every week in Groningen and on Texel. Annual deposition fluxes are comparable, about 300 $mBq \cdot m^{-1}$. A sudden increase in the annual flux by about 80% started at both stations in 1992 and has continued up to the present.

North Sea water samples from July 1993 and August 1994 have comparable $^{210}Po/^{210}Pb$ ratios in particulate as well as dissolved samples. Particulate activities of ^{210}Po and ^{210}Pb in August 1994 are two times the activities in July 1993, whereas the dissolved activities in August 1994 are only half the July 1993 activities. August 1994 activities have more in common with the October 1992 measurements than with July 1993 measurements.

Continental margin sediments and sedimentation

During 1995 a cruise was carried out to the Meriadzek terrace and Goban Spur in collaboration with the Department of Benthic Systems, using RV 'Pelagia'.

The material collected indicates a fast mineralization of organic carbon at the Meriadzek terrace, similar to the results obtained in the Goban Spur area.

Pistoncores were studied directly on board for the distribution of Heinrich layers by magnetic susceptibility measurements, and for their elemental composition by XRF. H1 and H2 were recognized in all cores collected, allowing a first regional correlation of sedimentation rates.

The BOBO lander was retrieved after a deployment of 12 months, and after initial problems with data recovery, appears to contain 6 months of current meter measurements and 8 months of salinity, temperature and transmission data.

Along the two transects covered during the 1994 campaign, surface nepheloid layers (SNL) and bottom nepheloid layers (BNL) of variable intensity were present at all stations. However, no intermediate nepheloid layer (INL) was measured. The BNL increases in thickness down slope with a decreasing intensity, suggesting gradual settling of particles along the transect. Transmission profiles of the water column along the Goban Spur transects show SNLs of variable intensity and thickness at all stations. INLs were not detected. BNLs range in thickness and intensity along the transects.

SEM analyses of the particulate matter within the BNL show that diatoms, faecal pellets and aggregates, and (resuspended?) coccoliths are the main components.

^{210}Pb and micropaleontological studies of the boxcores obtained in 1993 and 1994 show surface mixed layers of 20 cm at the shallowest station decreasing rapidly with station depth to 7.5 cm at the deepest station. Averaged over the last 7k years sedimentation rates are in the order of 3.5 $cm \cdot 1000\ y^{-1}$ at OMEX Stations B and C and around 3 $cm \cdot 1000\ y^{-1}$ at the other stations. Only at the upper slope station OMEX II is the rate much lower, probably confirming the local resuspension by bottom parallel currents. ^{210}Pb profiles of the boxcores collected in 1994 show that sediment mixing is highest in the shallower sediment samples; the mixed layer depth ranges from 20 cm at the shallowest station to 4-5 cm at the deepest. Downcore variations (0-20 cm) in org. C are low, ranging between approximately 0.7% at the surface and values slightly above 0.2% deeper down core.

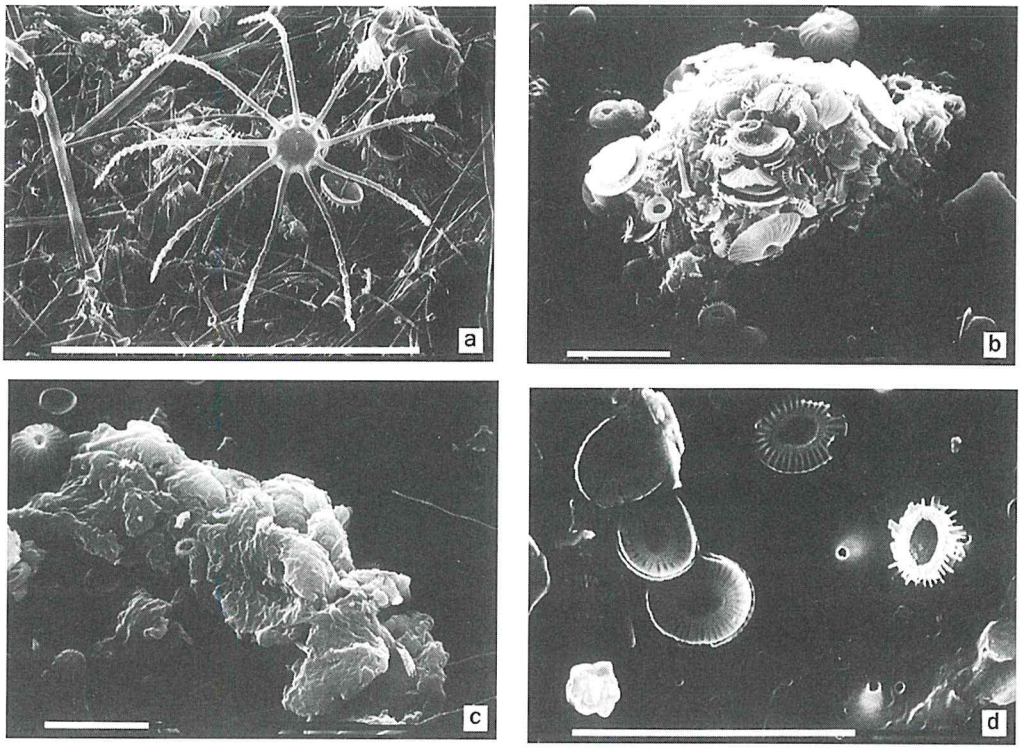
Mass accumulation rates and carbon burial rates along the transects indicate local non-deposition or erosion, possibly associated with formation of an INL.

Eastern North Atlantic Margin (ENAM)

Studies in the Faeroe Shetland Channel and the continental margin east of the Faeroe Islands (within the EC supported ENAM programme) relate the development of the Norwegian Sea Deep Water in the Norwegian Sea to the effects of overflow of the NSDW into the North Atlantic Ocean and include the determination of the changes induced by glacial periods and the deglaciation events.

Detailed measurements of the magnetic susceptibility of pistoncores ENAM 93-21 and 94-05, supported with data on grain size, foraminiferal content and oxygen isotopes show that the sedimentary record of contourite deposits at the Faeroe margin yields an extremely high resolution of paleoceanographic events. The circulation changes recorded at the Faeroe margin parallel the Greenland ice core isotopic records with the typical succession of abrupt temperature rises and gradual cooling (Dansgaard-Oescher cycles). The atmospheric and oceanic records appear to be synchronous and the oceans react within decades on climatic changes.

The seismic profiles of the eastern Faeroe continental margin show that the contourite development induced by the NSDW started during the Middle Miocene, and that subsequently a drift deposit at the mid-continental slope evolved.



Scanning electron microscope images of BNL filter samples. a: diatom skeletons (station D86-3); b: faecal pellet (station D86-5); c: aggregate (station D86-5); d: coccoliths, partially corroded (station D86-7); scale bar: a: 100 µm; b, c, d: 10 µm.

Deep Tow high resolution TOBI side scan sonar profiles of the NE Faeroe margin were recorded in 1995 and showed that repeated and extensive slumping and sliding has affected the lower and part of the middle continental slope. The slumped sediments have been distributed far into the Norwegian Sea and are likely to have merged with the Storegga slide deposits further east. Thermal subsidence of the Norwegian Sea floor is considered the main cause of the slumping and sliding.

Mud volcanoes and gas seeps

At the request of GEOMAR, NIOZ participated in an EC-supported study of gas seeps in the Sea of Ochotsk. Seismic profiles and bottom samples were studied during a visit of E. Basov to NIOZ, showing that anomalous bottom simulating reflectors (BSR) caused by the presence of gas do occur in the Sea of Ochotsk. It was also found that the area of recent gas seeps is situated at the boundary of the BSR zone of stability and in fact is governed by the geothermal gradient, which is locally lifted up because of a nearby volcanic zone.

Flocculation processes in the North Sea and western European estuaries

The *in situ* measurements of suspended particle (floc) size and settling velocity in the Elbe, Schelde and Gironde estuaries (EC MATURE Programme) indicated that the same range of floc size (1000 - 1400 µm) occurs in the three estuaries. All the particles observed were flocs, except possibly some mineral grains in the finest size fractions. Faecal pellets were hardly observed during the periods of measurement (April/May in 1993 and 1994). There is a predominant trend of floc size to become finer seaward in the estuaries, but this is not linked to a marked maximum floc size in the inner estuary. Only at very low salinity, between almost 0 and 1 ‰, do larger flocs occur, which may be related to the increase in salinity. It occurs only within a narrow salinity range; landward as well as seaward floc sizes are smaller. The larger flocs, when transported inward or seaward, are either broken up, or dispersed and mixed with other, smaller, flocs so that their number becomes relatively low.

Floc size maxima also occur at high suspended matter concentrations or during slack tide. The maximum size at high suspended matter concentrations is considered to be the result of the higher collision frequency of the flocs. The size maxima during slack tide are considered to be related to differential settling when current velocities are low. The *in situ* settling velocity was measured only in the Elbe and the Schelde and was mostly between 0.1 and 2 $mm \cdot s^{-1}$ with a maximum of

5.4 $mm \cdot s^{-1}$. This range is very similar to the settling velocities in the Ems and Tamar estuaries found by other authors. There is a tendency for the settling velocities to increase with floc size, but the variability is very large.

The intercomparison programme of *in situ* instruments for measuring floc size (eight different instruments) carried out in the Elbe estuary in June 1993 has shown that six instruments give comparable floc-size distributions and that the results of the other two instruments allow estimates of mean floc size, as well as of minimum and maximum floc size. The minimum size is a characteristic of the instrument used; the maximum size is primarily related to the concentration of the largest flocs (by number) and the volume of water that is measured, but is also affected by the instrument characteristics and the degree of floc break-up during sampling and measuring. Because the size distribution generally follows a log-probability curve, the differences in size range measured do not strongly influence the median size values. The variability between the results obtained with different instruments is such that a measurement programme can best be carried out with only one instrument in order to ensure a maximum of consistency.

Suspended matter in coastal waters of the East China Sea

In the Jiao Jiang estuary samples had been collected in November 1994 for analysis of suspended matter concentration, scanning electron microscope and X-ray diffraction. During this programme measurements of salinity and current velocity and direction were made by Chinese colleagues from the Second Institute of Oceanography in Hangzhou. The XRD results show that the suspended matter in the entire estuary comes from the Chang Jiang which flows into the East China Sea several hundred kilometres further north. An influence from the Jiao Jiang river itself could hardly be determined. Discharge and suspended load of the Jiao Jiang are very low during most of the year and are only high during a short period in the winter (the discharge then reaches 12000 m^{-1}, while during most of the year it is below 100 m^{-1} or even less than 1 m^{-1}; data for suspended load are not yet available). There is some variability in clay mineral composition in the estuary that is probably related to the turbidity maximum and primarily concerns the concentrations of montmorillonite (smectite).

Sedimentary development of the eastern Sunda forearc Basin

A compilation of on- and offshore evidence was made regarding the position of the island of Sumba in a developing Neogene forearc structure. This showed that Miocene subsidence of the now Sumba sediments was followed by deposition of an up to 600-m-thick volcaniclastic turbidite complex.

During middle and late Miocene, the depositional depth was below the then CCD. Reappearance of well-preserved foraminiferal assemblages and the present-day elevation level of the deposits indicate an uplift of 0.6 $mm \cdot y^{-1}$ since the late Miocene. The volcaniclastic components in the sediments appear to have been derived from a now extinct volcanic arc located to the south of Sumba. The Island of Sumba underwent a slight northward drift during the Neogene and a counter-clockwise rotation of 5°, possibly related to the late Pliocene collision with Australia. The Savu basin then developed into a presently inactive (Miocene) forearc basin and a Pliocene-Recent active North Savu Basin.

Contributors: *H. De Haas* (sedimentology), *E. Okkels* (sediment analysis), *W. Boer* (^{210}Pb and sediment analysis), *R. Kloosterhuis* (C/N analysis and SIMS), *Tj.C.E. Van Weering* (geology and sedimentology), *A. Vaars* (XRF and instrumentation), *H. De Stigter* (sedimentology), *W. Van der Werff* (seismic interpretation), *J. Kalf* (sediment and SPM analysis, flocculation), *D. Eisma* (sedimentology and flocculation), *J.P. Beks* (sedimentology, flocculation, radiochemistry).

DEPARTMENT OF MARINE BIOGEOCHEMISTRY AND TOXICOLOGY

As a consequence of the reorganization of the scientific departments of NIOZ, the marine biogeochemists and toxicologists merged in the new Department of Marine Biogeochemistry and Toxicology. Despite the fact that the biogeochemical and toxicological laboratories are physically separated, the scientific and social integration proceeds smoothly as a consequence of an already existing collaboration.

The major research themes are:
—1. Resistant bio-macromolecules: investigating the short- and long-term variations in the preservation of organic carbon and the mechanisms of oil genesis.
—2. Palaeo-environmental indicators: examining palaeo-environments and the astronomically induced changes thereof to discriminate natural from man-induced variations in the present-day climate.
—3. Anthropogenic compounds: studying the toxic effects of PAHs, PCBs and toxaphenes, and their metabolites, on marine biota.

Intensive collaborations with the Molecular Mechanics group of the Delft University and the newly established Organic Geochemistry Unit of the Earth Sciences Department of the Utrecht University have to be mentioned as well. The latter collaboration is a permanent one through part-time positions of both Jaap S. Sinninghe Damsté and Jan W. De Leeuw at the University of Utrecht.

A few findings of the last year are highlighted.
—The recognition of highly resistant, non-saponifiable polyethers in marine micro-algae and marine sediments significantly contributes to our understanding of the mechanisms of formation of marine source rocks and marine oils and sheds light on the global cycling of organic matter presently and in the past.
—Contrary to what is generally believed, carotenoids, and in particular their diagenetic polyaromatic derivatives, are highly resistant and sometimes highly abundant in aromatic fractions of sediment extracts and oils. They are specific markers for certain biota and palaeo-environmental conditions, whereas the polyaromatic nature of these naturally occurring compounds might play a role in mutagenetic transformations.
—Genetic damage (DNA strand breaks) in the pyloric caeca of the common seastar *Asterias rubens* and in the liver of the flatfish *Limanda limanda* (dab) increases with increasing concentrations of chlorinated biphenyl congeners.
From the instrumental point of view it is noteworthy to mention that the recently implemented irm-GC/MS apparatus operates very smoothly so that compound-specific stable carbon isotope values are being determined almost routinely in many samples.

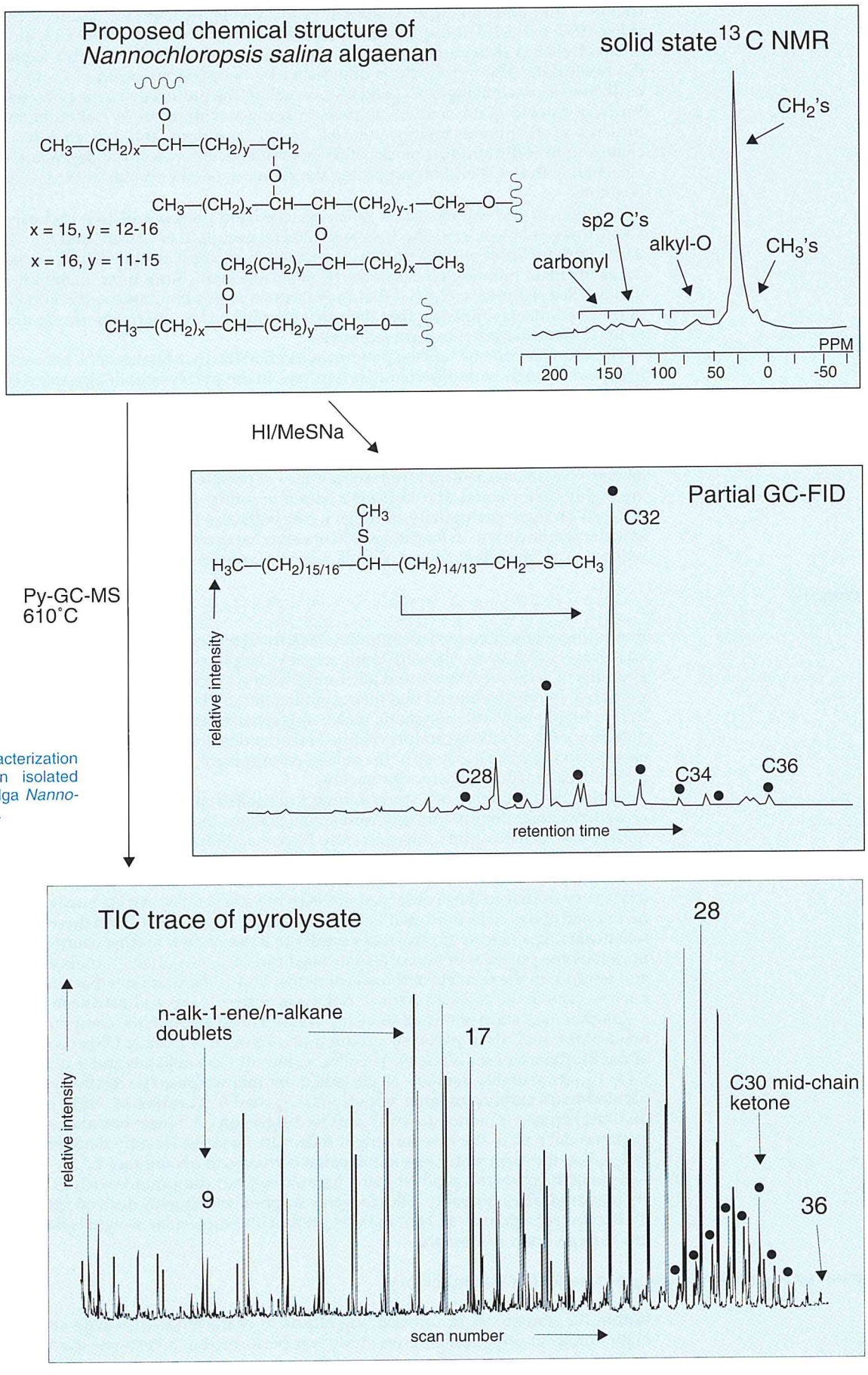
1. RESISTANT BIOMACROMOLECULES

The search for resistant biomacromolecules in organisms, suspended matter, dissolved organic matter and sediments was continued this year to increase our understanding of biogeochemical cycles, to characterize molecularly the bulk of sedimentary carbon (*i.e.* kerogen), and to unravel mechanisms of petroleum formation in the marine environment.

Marine algaenans

Over the last decade a wide variety of insoluble, non-hydrolysable aliphatic biomacromolecules have been recognized in freshwater green microalgae (algaenans), in higher plant cuticles (cutans) and periderm tissue (suberan), in inner seed coats of fresh-water plants (tegmens), in spores and pollen grains (sporopollenins) and in resins (polycadinenes). Because of their chemical stability and their resistance against bacterial decay, these macromolecules are selectively preserved and make up a significant part of organic carbon in non-marine sediments ranging in age from Recent to over 300 million years. They can eventually act as the source of high-wax crude oils upon burial and thermal cracking. However, up to now, such 'natural polyethylenes' have been encountered almost exclusively in freshwater algae and higher plants. Whether these alphatic biomacromolecules also occur in marine organisms was unknown. Therefore four marine green microalgae (Chlorophyceae) and two marine microalgae of the class Eustigmatophyceae were investigated.

Freeze-dried algal cells, cultured at the Department of Biological Oceanography (A.A. Noordeloos), were extracted and the residues were treated with base and acid to remove free lipids, ester-bound lipids, proteins and carbohydrates, respectively. These treatments afforded 1 to 2% of an insoluble residue, *i.e.* algaenan from both the chlorophytes and the eustigmatophytes. The algaenan of the microalga *Nannochloropsis salina* was analysed by solid state ^{13}C NMR. The



Chemical characterization of the algaenan isolated from the microalga *Nannochloropsis salina*.

chemical shift maximizing at 33 ppm indicates the highly aliphatic nature of this algaenan since at least 95% of the NMR response is represented by this chemical shift of CH_2 moieties. The results of pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) of this algaenan agreed with the NMR data. The pyrolysate is dominated by homologous series of C_5 to C_{36} *n*-alkanes and n-alk-1-enes maximizing at C_{16} and C_{28}, revealing the presence of long polymethylenic moieties. Series of co-eluting ω^{17} and ω^{18} mid-chain ketones with up to 34 carbon atoms pointed to the presence of ether bonds mainly at the ω^{17} and ω^{18} positions, and indicated the maximum carbon chain length of the building blocks of the macromolecules. Chemical degradations of the *N. salina* algaenan with RuO4 and HI supported the presence of ether bonds at the C-1 and the ω^{17} or ω^{18} positions.

Analyses of the extracts of *N. salina* revealed the presence of free and ester-bound C_{30}-C_{32} alken-1-ols and C_{30}-C_{36} *n*-alkadiols with alcohol groups at ω^{17} or ω^{18} and C_1. The structural similarity of these lipids and the units in the algaenan strongly indicate that the specific C_{30}-C_{36} diols act as the main building blocks of the *N. salina* algaenan. Since their unambiguous identification in Black Sea sediments, C_{30}-C_{32} diols have shown to be ubiquitous and relatively abundant in all marine sediments, implying that their macromolecular counterparts are significant contributors to the organic matter of marine sediments.

The abundant alkene/alkane patterns noticed in the pyrolysates of *N. salina* algaenan were also observed, though with different distributions, in the pyrolysates of algaenans of the other algae. Because homologous series of alkenes and alkanes often dominate pyrolysates of marine kerogens isolated from both Recent and ancient sediments, it is concluded that algaenans, although not necessarily derived from the microalgae investigated here, are major contributors to marine sedimentary organic matter. Further support of this comes from stable carbon isotope studies of alkenes and alkanes isolated from pyrolysates of marine kerogens (see below). Their $\delta^{13}C$ values are highly uniform and thus indicate a common source, *i.e.* algaenan.

Based on these preliminary findings we hypothesize that marine algaenans represent a major sink of organic carbon in marine sediments and that upon burial in the Earth crust these materials will act as an important source of *n*-alkanes in marine petroleums.

Kerogens

Pyrolysates of the kerogens of immature Messinian sediments (Vena del Gesso, Italy) representing one evaporative cycle showed many organic sulphur compounds as well as relatively high amounts of series of alkanes and alk-1-enes. Using $Li/EtNH_2$ this series of kerogens was desulphurized. Pyrolysis showed that the remaining part of these kerogens consisted almost exclusively of a highly aliphatic polymeric matrix (algaenans, see above). Differences in the distribution patterns of the pyrolysis products before and after desulphurization yield information concerning changes in the standing stock in the palaeo-environment, as well as in palaeo-environmental conditions as a function of evaporitic cycling.

During the first phase of a study aiming to establish climatological land-sea correlations and to recognize climatological and environmental changes in stratigraphically-related well-laminated marine and lacustrine late Miocene-early Pliocene Mediterranean sediments from Greece and Italy, a series of lacustrine samples were subjected to Py-GC-MS. To our surprise the pyrolysates of these samples contained, apart from abundant series of alkanes and alk-1-enes, mid-chain ketones very similar to those observed in the pyrolysates of the marine eustigmatophyte algaenans mentioned above. This indicated that the bulk of the organic matter in these sediments consists of freshwater algaenans with structures similar to those of their marine counterparts. This was supported by the presence of the corresponding lipids, C_{28} - C_{36} $1,\omega^{13\text{-}17}$ diols as well as similar triols and tetraols, in the extracts of these sediments. This is the first time that such structural relations are observed in the resistant parts of cell walls of freshwater and marine microalgae.

Another indication of this relationship was obtained through the compound-specific stable carbon isotope analysis of pyrolysis products of a kerogen of a lower Oligocene evaporitic sequence of the Mulhouse basin (France). The $\delta^{13}C$ values of the n-alkanes and n-alk-1-enes ranging from C_9 to C_{20} were highly similar, -30 per mil±2 per mil, whereas the relatively highly abundant isoprenoid hydrocarbons ranging from C_{13} to C_{20} had $\delta^{13}C$ values of -25±1 per mil. This indicates that this kerogen is a mixture of at least two algaenans, a 'linear' one and an isoprenoid one. The isoprenoidal part of the kerogen might reflect an algaenan recently demonstrated to occur in the cell wall of the fresh water green microalga *Botryococcus braunii* race L.

Among the pyrolysis product many organic sulphur compounds such as alkylthiophenes were encountered. They probably reflect organic sulphur constituents derived from intermolecular sulphurization of a diverse suite of initially present low-molecular-weight lipids since their $\delta^{13}C$ values varied very considerably.

Dissolved and particulate organic matter (DOM and POM)

Within the framework of our ongoing efforts to characterize dissolved and particulate organic matter molecularly, a comparative study was performed to investigate the recovery and chemical

nature of DOM applying tangential ultrafiltration (500 and 1000 D filters). To this end samples obtained from the North Sea and the Ems estuary were processed. A critical step in the isolation procedure is the dialysis after concentration of DOM by tangential ultrafiltration to free the samples from salt, before they can be analysed by flash-pyrolysis and chemolysis methods. Although calculations predicted differently, it has become clear that the high salt concentrations in the samples obtained by filtration over 500D filters is prohibitive for the isolation of DOM. The balance of concentration of DOM via tangential ultrafiltration and the loss of it during subsequent dialysis turned out to be much better when 1000D filters were used.

The DOM samples from the Ems-Dollard were desalted using diafiltration. Water was removed from these samples by evaporation. The thus obtained DOM powder samples were analysed by flash pyrolysis-gas chromatography-mass spectroscopy. Pyrolysis products derived from carbohydrates were encountered in the pyrolysates of all Ems-Dollard DOM samples. Alkylpyrroles, alkylphenols and alkylbenzenes were also present. Possible precursors of the alkylphenols are lignins, partially degraded lignins, tannins and polyphenolic macromolecules biosynthesized by algae in the river.

POM samples from the Ems estuary will be separated in fractions according to grain size using the so-called SPLITT method. These fractions are analysed by Accelerated Mass Spectrometry (AMS) and common isotope mass spectrometry to determine differences in their $^{14}C_{org}$ and $^{13}C_{org}$. Characterization of the organic matter with pyrolysis methods will enable the comparison of the molecular composition of DOM and POM and will reveal relations between isotope contents and the nature and origin of organic matter in the estuary.

The SPLITT method has also been applied successfully on a suite of sediment samples of the Washington coast. The organic matter thus fractionated is subjected to AMS and will also be analysed by Py-GC-MS.

Preliminary carbon isotope measurements of a sample of suspended matter from the Ems-Dollard estuary, the extractable lipids and the residue after extraction all show a ^{14}C content of 79% (1870 year BP). This indicates a substantial contribution of eroded peat to the total particulate organic matter.

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2. PALAEOENVIRONMENTAL INDICATORS

A substantial part of the research activity of the Department is focused on the development and use of proxies for environmental conditions in the past and is part of the PIONIER programme 'Molecular Palaeontology of Marine Sediments'. The process starting with the synthesis of a biolipid and ultimately ending with the preservation of a geolipid in the sedimentary record is very complex but has to be unravelled if molecular signatures of ancient sediments are to be decoded. Recently, it has become clear that natural sulphurization and the stable carbon isotopic composition of lipids play an important role in preserving palaeoenvironmental information and are, therefore, the focus of study. Furthermore, attention has been given to the determination of sea-surface palaeo-temperatures and to the understanding of catastrophic events in the geological past.

Diagenetic and catagenetic pathways

—*Natural sulphurization.* To obtain more information on the incorporation of sulphur into organic material during early diagenesis, laboratory simulation experiments of the natural (hydro-)sulphurization process were performed. In these experiments model compounds (alkenes, dienes, ketones, *etc.*) were reacted with hydrogen polysulphide ions in a two-phase system (aqueous/ethyl acetate), with and without a phase transfer catalyst (PTC) at 50°C. With 1-tetradecene as a substrate, the use of a PTC yielded about 70% dimeric sulphides after one week. If no PTC was added, about 50% of the substrate was transformed into sulphur-containing products after six weeks. The main difference between these experiments is that the use of a PTC yields mainly dimeric di- or polysulphides, whereas without this PTC the main products formed are dimeric monosulphides. Retinol was used as a model compound for β-carotene as it contains a similar system of conjugated double bonds. It is a very reactive compound (under PTC conditions) and within one week all substrate had disappeared and products were formed. Products are formed inter- as well as intramolecularly resulting in the incorporation of up to five sulphur atoms.

In addition, TOC-rich samples (0-3 m deep in the sediment) from the Peru upwelling region have been analysed at the molecular level for organically-bound sulphur. This will provide additional data on the timing of the natural sulphurization process. (Co-operation with Dr. T. Eglinton, Woods Hole Oceanographic Institution.)

—*Thermal stability of OSC and sulphur-containing geomacromolecules.* To elucidate at what level of thermal maturity OSC (organic sulphur compounds) and sulphur-containing geomacromolecules can still be used for palaeoenvironmental reconstruction, an immature sulphur-rich sample from the Messinian Gessoso-Solfifera Formation in the Vena del Gesso Basin (Italy) was artificially matured at different conditions (160-330°C; 72 h) by means of hydrous pyrolysis. Results indicate that relatively mild maturation conditions already have a large impact on the abundance and distribution of OSC. Sulphur-containing geomacromolecules break down into smaller molecules, probably due to cleavage of weak (poly)sulphide bridges. Low-molecular-weight OSC, which have been used as biomarkers, are still present at relatively high levels of thermal maturity (330°C). Recent investigations of oxygen-linked compounds have shown that specific biomarkers can be sequestered simultaneously by sulphur and oxygen. This was exemplified by a study of the sequestration of C_{37} and C_{38} alkenones, biomarkers that are widely used to assess palaeo sea surface water temperatures, showing that these compounds are easily 'hidden' in sediments and only appear after mild thermal maturation. Another immature sulphur-rich sedimentary rock from the upper Cretaceous Ghareb Formation (Jordan) was also studied by hydrous pyrolysis (200-365°C; 72 h). The preliminary results seem to fit in well with those obtained from the Vena del Gesso Basin. The concentrations of n-alkanes, isoprenoid alkanes, steranes and hopanes increase with increasing maturation temperature, indicating that they were sequestered in high-molecular-weight fractions.

—*Carotenoids.* Carotenoids are C_{40} components with a conjugated double bond system in the acyclic isoprenoid chain that are used as accessory pigments by photosynthetic organisms. Because of these double bonds, carotenoids are extremely sensitive to oxidation. Therefore, their geological preservation potential is generally considered low. Recently, however, we discovered a whole suite of diagenetic products of the diaromatic carotenoid isorenieratene, derived from strictly anaerobic photosynthetic green sulphur bacteria, in rock samples ranging in age from Ordovician to Miocene. These compounds were formed by (i) natural sulphurization of the double bonds, (ii) cyclization and aromatization of the isoprenoid chain, and (iii) chain-shortening. A similar suite of diagenetic products derived from the carotenoid *b*-carotene was identified and is apparently formed by the same processes. This formation, however, requires an additional process, *i.e.* the aromatization of the terminal cyclohexenyl moieties of *b*-carotene. This leads to a slight alteration of the *b*-carotene backbone, *i.e.* loss of two methyl groups. The diagenetic products of isorenieratene and *b*-carotene indicate that carotenoids can be preserved in the geosphere over geological periods of time and can be used as palaeo-environmetal indicators, *e.g.* for the assessment of photic zone anoxia. However, their carbon skeletons may not be directly recognizable due to the presence of additional aromatic rings in the isoprenoid chain. That is probably the reason why these compounds, present in some of the best-studied sedimentary rocks of the world, have not been discovered until now.

—*Gammacerane.* A new diagenetic route for the formation of gammacerane from tetrahymanol is proposed; in addition to dehydration and hydrogenation, sulphurization and early C-S cleavage are shown to be important in the pathway of formation, especially in marine sediments. Evidence is twofold. Firstly, relatively large amounts of the gammacerane skeleton are sequestered in S-rich macromolecular aggregates generated by natural sulphurization of functionalized lipids. Selective cleavage of polysulphide linkages with MeLi/MeI led to formation of 3-methylthiogammacerane, indicating that the gammacerane skeleton is primarily bound via sulphur at position 3, consistent with the idea that tetrahymanol, or the corresponding ketone, is the precursor of gammacerane. Secondly, upon mild artificial maturation of two different sediments using hydrous pyrolysis, gammacerane is released from S-rich macromolecular aggregates by cleavage of the relatively weak C-S bonds. The stable carbon isotopic compositions of gammacerane and lipids derived from algae, cyanobacteria and green sulphur bacteria (likely food sources for ciliates) in the Miocene Gessoso-Solfifera and Upper Jurassic Allgäu Formations indicate that gammacerane is derived from bacterivorous ciliates which were partially feeding on green sulphur bacteria. This demonstrates that anaerobic ciliates living at or below the chemocline are important sources of gammacerane, consistent with the fact that ciliates only biosynthesize tetrahymanol if their diet is deprived of sterols. This leads to the conclusion that gammacerane is an indicator of water column stratification, which solves two current enigmas. Firstly, it explains why gammacerane is often found in sediments deposited under hypersaline conditions but is not necessarily restricted to this type of deposits. Secondly, it explains why lacustrine deposits may contain abundant gammacerane since most lakes in the temperate climatic zones are stratified during summer.

—*Ether lipids.* In collaboration with the organic geochemistry group of Utrecht University, the free and bound lipid fractions of Recent and ancient (up to 18 Ka) Indian Ocean sediments collected during the Netherlands Indian Ocean Program 1992-1993 have been studied. High amounts of biphytane diols with 0 to 3 rings and ether lipids containing cyclised C_{40} isoprenoids were identified. Chemical degradation with HI and $LiAlH_4$, which cleaves ether-bound compounds and converts the released alkyliodides into alkanes, of several extracts from a number of other Recent

(Black Sea) and ancient sediments (Miocene Monterey Fm.) revealed that their concentration of acyclic and cyclic biphytanes varied by two orders of magnitude. Since these compounds are biosynthesized by Archaebacteria (*i.e.* methanogenic, thermophilic and acidophilic bacteria) only and since they are found in sediments from normal marine depositional environments, they probably derive from methanogenic bacteria and more specifically *Methanosarcina barkeri*. Several lines of evidence suggest that these methanogens are living in anoxic micro-environments in the water column (*i.e.* the guts of zooplankton). The δ^{13}C-values of the cyclic biphytane skeletons are rather constant between -19 and -22 per mil in different depositional environments indicating that they are derived from similar species of methanogens using the same carbon source. These lipids show potential to trace palaeo-oxygen minimum zones.

—*Highly branched isoprenoids (HBI).* Another striking feature of the Indian Ocean sediments is the abundant presence of alkenes with C_{25}, C_{30}, and C_{35} HBI skeletons, some of which are also present in the diatom species *Rhizosolenia setigera* and *Haslea ostrearia*. The $C_{35:7}$ HBI alkene was identified by hydrogenation to its saturated counterpart. To the best of our knowledge this HBI alkene has not yet been reported in biota or sediments. By analogy with the source organisms proposed for the C_{20}, C_{25}, and C_{30} counterparts of the C_{35} pseudohomologue, we propose diatoms as the most likely source organisms for this compound. The δ^{13}C-values of the HBI alkenes show a remarkable variability. Differences of up to 17 per mil were measured for C_{30} HBI alkenes. These differences seem to be related to differences in growth rate and cell size of the diatoms biosynthesizing the HBI alkenes.

—*Hopanes.* Significant advances in the understanding of dia- and catagenesis of hopanes have been achieved. Firstly, a detailed study has been undertaken of the carbon skeleton distribution of C_{27}-C_{35} hopanes in four different samples from the Calcaires en Plaquettes, the Ghareb and the Hauptdolomit Fms. In the most immature samples hopanes occur predominantly sulphur-bound whereas in more mature samples the free hopanes predominate and show a maximum at C_{31}. These changes can be explained by C-C and C-S bond cleavages of the side chain of sequestered C_{35} hopane skeletons during early thermal maturation. These changes could be mimicked by artificial maturation using hydrous pyrolysis of the immature Ghareb sample. Secondly, in co-operation with the Delft University of Technology, computational methods based on molecular mechanics were developed to calculate the isomerization of homohopanes. These methods were calibrated against an artificial maturation set obtained through hydrous pyrolysis of an immature marl from Italy and a natural maturation set and provide detailed insight into the timing and extent of isomerization reactions of sedimentary hopanes. These data provide a new tool for the reconstruction of the thermal evolution of sedimentary basins.

Palaeo-environmental assessment

—*Oceanic anoxic events.* During the Jurassic and Cretaceous several so-called oceanic anoxic events (OAE) took place, one of the most widespread at the Cenomanian/Turonian boundary (*ca.* 91 Ma ago). According to numerous models, these OAEs led to enhanced preservation of organic matter in the sedimentary record (deposition of black shales) through anoxicity in the water column. With the molecular fossil isorenieratane (and derivatives thereof, see above) it has become possible to test this hypothesis. Therefore, black shales from the Cenomanian/Turonian boundary in DSDP/ODP cores from different sites in the North Atlantic were analysed. Preliminary results indicate that photic zone anoxia indeed occurred during the Cenomanian/Turonian OAE but was restricted to the southern North Atlantic (palaeo-latitude 0°-15°N). Interestingly, in this geographical area the organic carbon accumulation rates are a factor of five to ten higher than at greater palaeo-latitudes in the Cretaceous North Atlantic. These data have important implications for the models explaining OAEs and seem to favour the restricted circulation model.

A set of ten samples from Lias ε marls from SW Germany, representative of the early Toarcian anoxic event, were also analysed. Preliminary results indicate that photic zone anoxia occurred during this OAE as well. However, chemocline excursions, deduced from the relative abundance of isorenieratane, do not correlate with those deduced from the concentrations of the nickel or vanadium porphyrins.

—*Hypersaline palaeo-environments.* Compound-specific carbon isotope analyses of biomarkers present in marls and gypsum sediments from a Miocene hypersaline deposit in the Northern Appennines showed that all biomarkers derived from marine organisms are surprisingly enriched in ^{13}C, with δ^{13}-values ranging from -15 to 19 per mil. Only terrestrially derived long chain *n*-alkanes have δ^{13}-values of *ca* -30 per mil. The cause for this phenomenon is at present unkown but it has been documented in the literature that cyanobacterial mats in hypersaline environments can be substantially enriched in ^{13}C. Further research into other hypersaline deposits may shed some more light on this matter.

—*Menilite Shale.* The Menilite Shale in Southeast Poland is a sequence of flysch sediments of Early Oligocene age varying in thickness from several tens to over 300 m. It is composed of black shales

with intercalated sandstones and siliceous sediments. The Menilite Shale is the most likely source rock for the majority of Carpathian oils. In the outermost overthrust unit, the Skole nappe, black shales are associated with diatomites and siliceous shales being intercalated in different stratigraphic positions. A detailed biomarker study of an immature black shale (TOC 17.2%) serves as a suitable example to demonstrate the occurrence and distribution of diatom-derived highly branched isoprenoids (HBIs) and other biomarkers related to diatomaceous sediments.

In the saturated hydrocarbon fraction the C_{25} HBI hydrocarbon is one of the most abundant individual compounds (0.14 $mg \cdot g^{-1}$ TOC). The C_{20} HBI is also present though in lower concentration. The by far largest part of the C_{25} HBI skeleton is present as sulphides (2.1 $mg \cdot g^{-1}$ TOC). The C_{25} HBI was also released upon desulphurization of the polar fraction with Raney-Nickel (0.09 $mg \cdot g^{-1}$ TOC) showing its partial incorporation into the macromolecular organic matter. Free and sulphur-bound C_{25} HBIs occur in a concentration of 3 $mg \cdot g^{-1}$ TOC. This carbon skeleton is present for 95% in a sulphur-bound form.

The quantitative distribution of C_{25} HBIs clearly demonstrates that sulphur incorporation is the prevailing diagenetic pathway for these compounds and indicates a substantial contribution of diatoms to the organic matter even in shales where siliceous diatom skeletons are not preserved. The occurrence of HBIs is consistent with the presence of diatomite intercalations within the sedimentary sequence of the outer Flysch Carpathians. Investigation of samples representing different facies of the Menilite Shale will reveal how general C_{25} HBIs are and, hopefully, tell us more about the specific conditions leading to accumulation of the diatom marker in the geological record.

—*Kimmeridge Clay Formation (UK).* Thirteen outcrop samples were taken of the Upper Kimmeridge Clay at its type locality in Dorset (UK). Like three similar samples of the Lower Kimmeridge Clay studied last year, these all contain a large array of diagenetic products of isorenieratene, pointing to the presence of an anoxic water column extending into the photic zone. Thus, despite the highly variable lithology of the samples, photic zone anoxia prevailed at least during some time of their deposition. From the biomarker distributions it is seen that the species composition of the algae, for instance the relative contribution of dinoflagellates, changed through time. The stable carbon isotopic composition of the kerogen is positively correlated with TOC (total organic carbon) content, but individual biomarkers do not show this trend. This means that the increase in $\delta^{13}C$ of the kerogen with increasing TOC cannot be explained, as suggested in the literature, by enhanced reworking of organic matter in the water column for the organic-lean samples.

—*Calcaires en Plaquettes Formation (France).* Collaboration was started with the Université Paris-Sud Orsay and the École Nationale Supérieure de Chimie de Paris concerning the Upper Jurassic lagoonal sediments of which we analysed one sample last year. This time one massive limestone layer and four texturally different laminae approximately 1 mm thick were sampled. The inorganic part of the sediments and the off-line pyrolysates of the kerogens are studied by the French groups. Our share in the project includes the study of the flash-pyrolysates of the kerogens, and the biomarker and compound-specific stable carbon isotopic analysis of the extractable organic matter.

—*Extant and fossil leaves.* To understand the influence of climatic changes on the distribution and carbon isotopic composition of terrestrial biomarkers encountered in marine sediments (*e.g.* long chain n-alkanes) a project was started with the Laboratory of Paleobotany and Palynology of the University of Utrecht. Modern and buried leaves (*ca* 10-15 years old) of the birch *Betula pubescens* were analysed for surface lipids, extractable lipids and ester-bound lipids. Dramatic changes in the lipid compositions were observed between modern leaves and buried leaves indicating extensive degradation. Preserved compounds like long-chain n-alkanes and fatty acids show significant differences in ^{13}C-contents with the modern leaf lipids being 2-6 per mil more depleted than the buried leaves. Detailed investigation of samples from another core will be undertaken in order to understand the influence of climate changes and diagenesis on these differences in $\delta^{13}C$-values.

—*Palaeo-upwelling.* The so-called U_k^{37} index, based on the ratio of two long-chain two- and three times unsaturated C_{37} methylketones occurring in several prymnesiophytes, is widely used to reconstruct palaeo-surface water temperatures. The same ratio can, however, be used to trace palaeo-upwelling because algae blooming in cold, upwelled water yield different ratios from those of algae living in non-upwelling regions. To confirm the potential use of this parameter in the Angola basin a laboratory study was performed with the coastal prymnesiophyte *Isochrysis galbana*, which produces the unsaturated ketones. Samples of this species cultured at different temperatures and nutrient conditions (Department of Biological Oceanography) show that nitrate and in particular phosphate limitation may induce major changes in the U_k^{37} ratios. These results show that the U_k^{37} as an indicator of palaeo-temperature and/or palaeo-upwelling has to be applied with great caution. The results obtained in the cases of phosphate and/or nitrate limitation suggest that, in contrast to what is generally believed, the unsaturated ketones are not involved in the regulation of membrane fluidity.

Biogeochemistry of Cretaceous/Tertiary boundary

Samples from several K/T boundaries at El Kef (Tunesia), Stevns Klint (Denmark) and Geulhem (The Netherlands) have been further investigated biogeochemically to determine the impact of meteorites on the environment and its constituting biota. At all sites gradual changes in biomarker profiles evidenced long-term natural climatic changes. However, the impact itself is very clearly indicated by the relatively major abundance of a highly specific biomarker, the C_{17} cyclopropyl-hexadecanoic acid. This compound is exclusively biosynthesized by fermenting bacteria. Its high abundances at and shortly after the impact, and the superb preservation of the organic matter, indicate that a massive anoxic fermentation has taken place, probably as a consequence of a massive input of fresh, though dead organic matter to the sediments.

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3. ANTHROPOGENIC COMPOUNDS

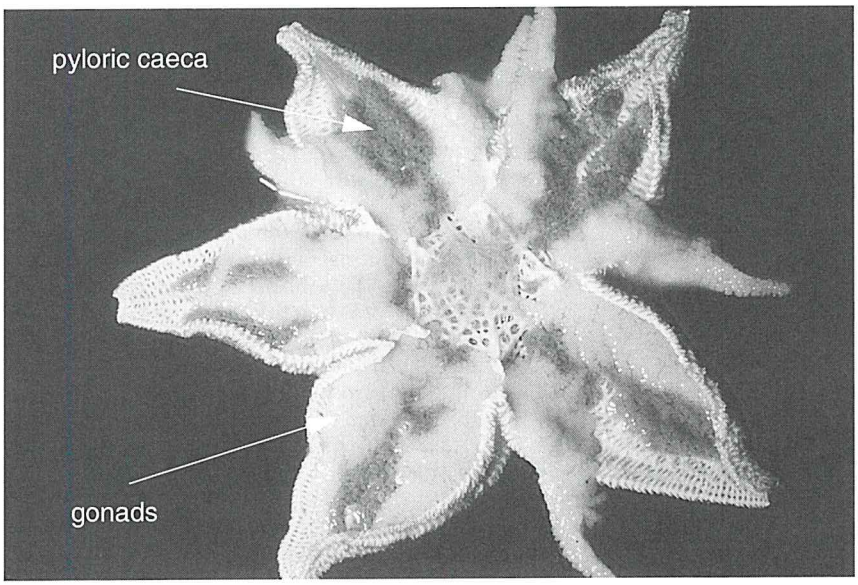
Biological markers of environmental contamination

—*DNA damage*. A research approach that evaluates both exposure to and effects of toxic substances to biota is the application of biological markers. Effects can be exerted on the molecular, biochemical, or cellular level, and may span physiological responses, behavioural changes and even changes in species composition. The research presented here focuses on the range from molecular to physiological.

During a North Sea survey (in the framework of the EC Indo-Dutch Joint Research Project on fate of contaminants and biomarkers), female seastars *Asterias rubens* were collected at locations with different sediment composition and various degrees of contamination. In homogenates of the pyloric caeca of the seastars, DNA strand breaks were measured by the alkaline unwinding assay. Impaired DNA integrity (enhanced strand breaks) was related to a combination of unfavourable environmental conditions, in particular enhanced exposure to PAHs and PCBs. Increasing strand breaks, however, did not relate to increasing concentrations of the metals Cd, Cu, Pb.

In a laboratory experiment, seastars were exposed to single chloro biphenyl (CB) congeners (-52, -77), a combination of the two, and benzo[a]pyrene (BaP) as a positive control. Preliminary results show the fraction of double stranded DNA ranging from 0.4 to 0.9, with large standard deviations and no significant differences between CB52, CB77, CB52/77 and BaP exposed groups. CB52 induces significantly more strand breaks than the control group (seawater or solvent exposed only).

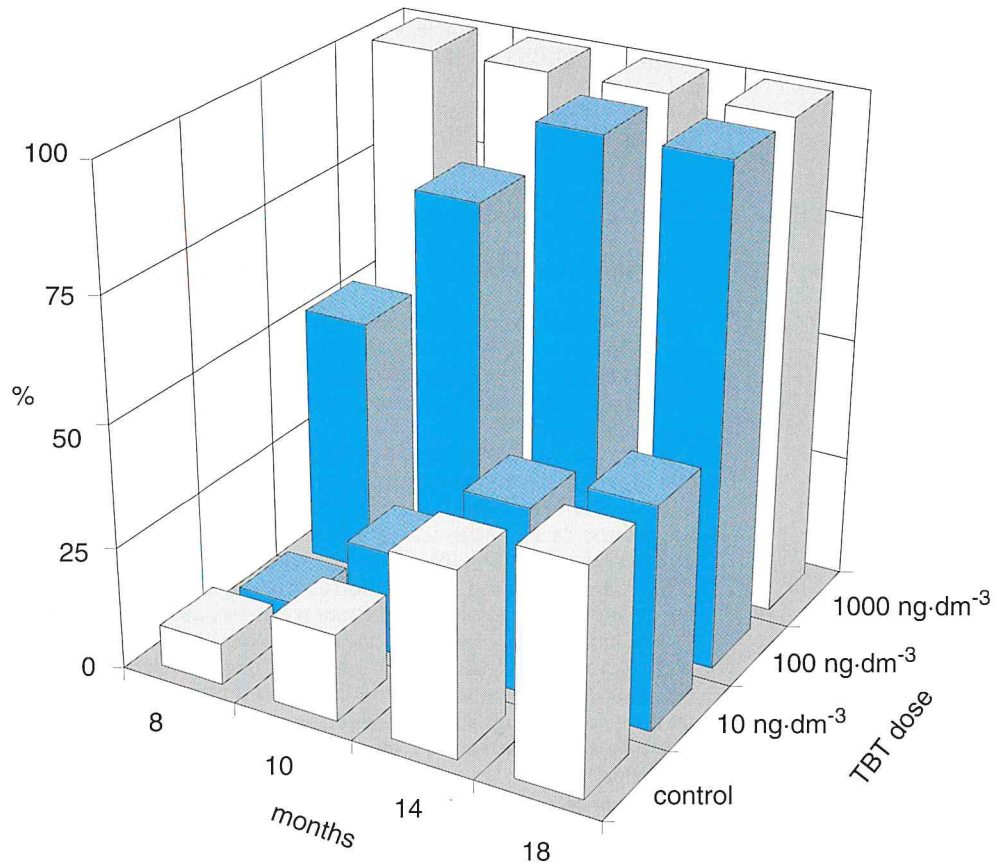
In an *in vitro* study with purified DNA, a clear dose-response relation was found between the fraction of DNA strand breaks and the concentration of CB28, CB52, CB77 and BaP.



Horizontal dissection of the seastar *(Asterias rubens)*; dorsal and ventral side separated. Photo: J. Everaarts.

—*Imposex in whelks*. Common whelks (*Buccinum undatum*) from the open North Sea show imposex, *i.e.* the development of male sexual characteristics in female prosobranch gastropods. This phenomenon is known since 1971, but only for coastal species. A correlation with shipping intensities has been established and tributyltin (TBT), the active biocide in anti-fouling paints, was ex-

pected to be the cause. To study the supposed cause-effect relationship, adult whelks were experimentally exposed to TBT. Juvenile *B. undatum* produced by the experimental specimens were also exposed *in ovo* or just after hatching, and only they developed male sexual characteristics (a penis and/or a vas deferens) in a dose-dependent manner. Already after 10 months more than 80% of the young *B. undatum* exposed to nominal TBT concentrations of ≥ 100 ng TBT·dm^{-3} developed such male sexual organs. Adult females, however, showed no signs of imposex, although they were exposed to the same TBT concentrations as their offspring for nine months.



Percentage of juvenile *Buccinum undatum* with male sexual characteristics at the age of 8, 10, 14 and 18 months at different TBT doses.

In 1995 high incidences (>95%) of imposex were again found in the Eastern Scheldt. The majority of the females examined showed a penis and/or a vas deferens, the most advanced stages of imposex in the common whelk known so far. However, egg masses were still produced and juvenile specimens were found, albeit showing imposex. Highest organotin concentrations were established in the digestive gland and lowest in the foot of the animals by our research partners (the Institute of Environmental Studies of the Free University, Amsterdam).

The incidence of imposex in whelks from the southern and central North Sea has been further inventoried. Additional evidence of imposex was found in areas with high shipping intensity where whelks did not show imposex 25 years ago (the German Bight and the southern North Sea). Whelks from areas with little shipping, limited fishing and no oil or gas mining in the northern North Sea showed very little or no imposex. Of the butyltin compounds, mono-butyltin dominated over di-and tributyltin. Triphenyltin was the dominant phenyltin compound. Concentrations the dominant compounds of both classes were significantly higher in areas with heavy shipping traffic than in areas with little shipping traffic.

PCB patterns in species of fish-eating mammals

Initiated by the Marine Chemistry Working Group of ICES, datasets on PCB concentrations in different species of fish-eating mammals from laboratories in four countries around the North Sea (Denmark, Norway, the United Kingdom, and the Netherlands) were combined for statistical treatment. The aim was to test and refine a kinetic model developed at NIOZ describing patterns of PCBs in lung-respiring predators in terms of uptake from food and biotransformation capacity. In this model, individual chlorobiphenyl congeners are divided into six different metabolic groups. Datasets involved seals (harbour seal, grey seal), otters and cetaceans (harbour porpoise

and a combined file on several species belonging to the family Delphinidae). Principal component analysis was used in the form of covariance bi-plots.

The results of different laboratories with regard to a single species merged without any problems due to application of similar analytical protocols. As such, the intercalibration exercises carried out within the framework of the ICES MCWG have been essential to the success of the project.

Between the species tested, clear differences in PCB transformation patterns were observed. The ability to metabolize congeners with unsubstituted *ortho-* and *meta*-positions and one *ortho*-chlorine atom increased in the order: otter < cetaceans < seals. In contrast, the ability to metabolize *meta-, para-* unsubstituted congeners with two *ortho* chlorine substituents increased in the order: cetacean < seal < otter. Especially the latter is interesting, since the order represents the association of the different animals with the terrestrial environment. Metabolism of this type of congeners is believed to be mediated by cytochrome P450 2B isozymes. Evolutionarily, this subfamily of isozymes is assumed to have gained importance when animals had to develop enzyme systems able to detoxify poisonous compounds produced by higher terrestrial plants, or combustion products originating from forest fires.

It also became clear that considerable differences may exist in biotransformation rates of congeners belonging to the same metabolic group, as defined by the location of the vicinal hydrogen atoms and the number of *ortho*-chlorine atoms. Thus, chlorine substitution at other positions influences metabolic rates too. CB-118 and CB-101 seem to be easily metabolizable representatives of the metabolic groups to which they belong. CB-149, possessing *meta-, para-* unsubstituted positions in combination with three *ortho*-Cl atoms, appears persistent in cetaceans but metabolizable in seals and otters.

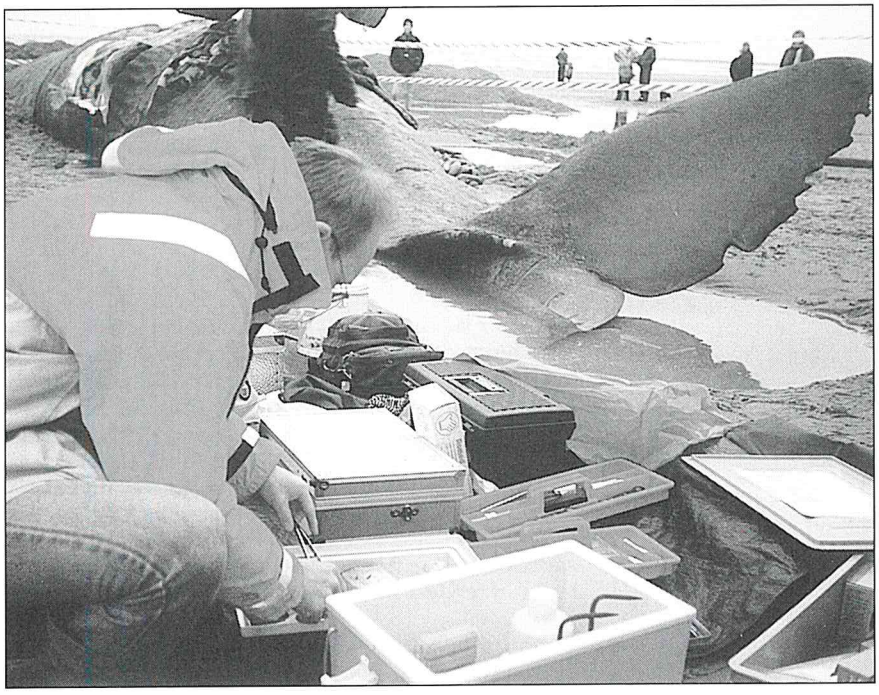
Only by virtue of the large number of data for each species did it become clear that PCB patterns within a single species are not entirely constant but differ systematically in a concentration-dependent manner. Especially the contribution of PCB congeners that can easily be metabolized by the cytochrome P450 system decreased with increasing concentrations of persistent PCB congeners. Induction of certain isoforms of the cytochrome P450 system at higher concentrations offers the most likely explanation for this phenomenon.

In-vitro biotransformation of polyhalogenated organic contaminants

In this study, liver preparations of reently dead animals were used to test whether certain lipophilic polyhalogenated organic contaminants can be metabolized by the cytochrome P450 system of marine mammals or birds. Most samples were obtained from animals that died at 'Ecomare', the educational centre for the North Sea and Wadden Sea on Texel. Other samples were obtained from the Dolphinarium at Harderwijk, the University of Leiden, and the Research Institute of Toxicology of the University of Utrecht.

Microsomes of harbour seal, harbour porpoise, white beaked dolphin, sperm whale, eider duck and albatross have been prepared. Microsomes of laboratory rats were also used to test the assay.

From the frozen homogenates, microsomal fractions were prepared by (ultra-) centrifugation. Microsomes contain the smooth endoplasmatic reticulum consisting of a phospholipid membrane from which the enzymes emerge like islands from the sea. To check whether the microsomes were

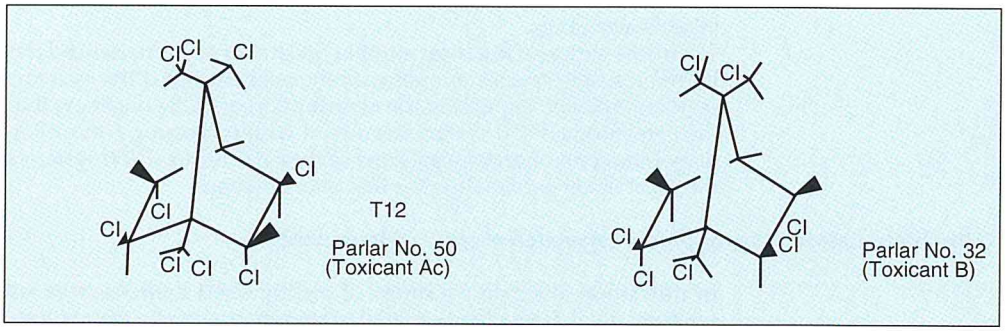


Microsome collecting from a sperm whale. On 13 January 2 p.m. a telephone call from dr. R. Kastelijn (Dolphinarium Harderwijk) reached NIOZ: three males of about 14 m had that morning stranded near The Hague. Equipped with a special sampling kit we arrived in The Hague at 6.30 p.m. The body cavity of one animal, which had stranded alive, had already been opened, liver homogenates were prepared on the beach using a 220V generator mounted in a police pick-up. All samples were frozen in liquid nitrogen by 8 p.m.
Photo: Barbara Boon.

in a biochemically viable condition, two standard biochemical assays for the activity of cytochrome P450 1A and 2B isozymes were carried out (ethoxyresorufin-O-deethylase (EROD) and Aldrin-epoxidase assay, respectively).

When compounds are persistent in the test they are likely to bioaccumulate in these marine top predators. Then, residues of such compounds may be measured in lipid-rich tissues. On the other hand, when compounds are rapidly degraded in the test, the absence of a residue in wildlife does not mean that the animal was not exposed to the compounds. In this case any remaining toxicity of the compound is likely to be due to metabolites instead of the original structure.

All microsomes isolated showed EROD activity. Metabolic rates towards technical toxaphene differed enormously between animal species. Rat and harbour seal were by far the most active. Some activity was found for the white-sided dolphin, the harbour porpoise and both bird species. Little, if any, activity was found for the sperm whale. These findings correlated well with the complexity of the toxaphene residues investigated by one of our research partners in this project, the Netherlands Institute for Fisheries Research at IJmuiden (RIVO-DLO), who found most toxaphene peaks in sperm whale blubber, but only very few in harbour seal blubber. One of the most persistent congeners seems to be 2-exo,3-endo,5-exo,6-endo,8b,8c,9c,10a,10b-nonachlorobornane, also known as Parlar 50 or T12. The peak of this congener often dominates in chromatograms of cetaceans. One of the more easily metabolizable congeners in the *in vitro* assay is 2,2,5-endo,6-exo,8b,9c,10a-heptachlorobornane (Parlar 32, ToxB.) At present, research is going on to isolate and identify the structure of its metabolites.



Structure of two persistent congeners in cetaceans.

Heavy metals in the marine environment

To investigate the distribution patterns and mobility of metals, surface sediments and epi-benthic invertebrates were collected during two surveys in the shallow coastal zone of Kenya and along transects radiating into the Indian Ocean perpendicular to the Kenyan coast.

In surface sediments, a significant increase was measured in the concentration of copper (Cu) and cadmium (Cd) along all transects and of zinc (Zn) along the most southern transect. Mean Cu and Cd increased from 5 to 30 $\mu m \cdot g^{-1}$ dry weight (dw) and from 0.01 to 0.34 $\mu m \cdot g^{-1}$ dw from shallow coastal (20 m depth) towards deep-sea sites (2000 m depth), respectively. These gradients were found during both the southeast and northeast monsoon periods. The shallow estuarine zone of the Sabaki river mouth showed significantly enhanced levels of total organic carbon, nitrogen and all metals analysed except Cd.

In crustacean species (penaeid prawns, spider crabs, swimming crabs and hermit crabs), the concentrations of Cu and particularly Cd were significantly above baseline levels. Zn levels were at about baseline levels or a little elevated. Lead, however, showed very low concentrations. Other species, such as brittle-stars and sea-urchins (echinoderms) and cuttlefish (cephalopods), generally showed identical distribution pattern of the metals. These results show that Cd concentrations in crustaceans exceed the maximum level for human consumption.

Dynamics of organic contaminants in the marine environment

A study was completed of the seasonal variation of PCB concentrations in surface sediments and four benthic invertebrates at a location in the western Wadden Sea. Concentrations in the sediment layer at 15 to 20 cm depth and in the sediment surface were constant within 20%, suggesting that varying inputs are effectively buffered by the sediment. Lipid-based concentrations in the snail *Littorina littorea*, the common mussel *Mytilus edulis*, the polychaete *Nereis diversicolor* and the lugworm *Arenicola marina* showed an annual cycle with values that differed by a factor of two to three. The maximum concentrations for the organisms are attained in different periods of the year, suggesting that species-specific processes are responsible for the observed annual cycles. Year-averaged concentrations for the higher chlorinated congeners could be roughly explained by the equilibrium partitioning theory. Concentrations of the lower chlorinated congeners were up to a factor of ten less than expected.

Contributors: *J.M. Everaarts, J.P. Boon, K. Booij, M.Th.J. Hillebrand, E. Van Weerlee, C.V. Fischer, H.M. Sleiderink, B.P. Mensink, C.C. Ten Hallers-Tjabbes, J.F. Mars, E. Roex, E. Kardinaal, J. Appelman, M.S. Helle.*

DEPARTMENT OF BIOLOGICAL OCEANOGRAPHY

The Department of Biological Oceanography was established to embrace the ocean ecosystem oriented projects of the former Departments of Pelagic Systems, Benthic Systems and Applied Marine Ecology (BEWON). It investigates the role of plankton and pelagic-benthic coupling in marine carbon and nutrient cycles. This contributes to a description of food web structure and a quantitative estimation of biomass, consumption and production of dominant species and functional groups in relation to their physical and chemical environment. Characteristic hydrodynamic and climatologic phenomena of great influence on primary and secondary production are studied in various regions. In the temperate zone, effects are studied of vertical stratification and of nutrient enrichment by river discharges and tidal mixing, upwelling and frontal mixing. Attention centres on physical/chemical conditions and trophic interactions that induce algal blooms. In tropical seas, the focus is on upwelling and wind-induced mixing, while in polar seas the effects of the extreme seasonal variation and ice-edge blooms are investigated. Properties of species are studied in the laboratory to understand their functioning in nutrient uptake kinetics, growth and reproduction, size-dependent prey selection and energy-balance under different experimental conditions. The interactions of species at different trophic levels, and ultimately the functioning of complex ecosystems, can be related to environmental conditions by multi-species experiments in mesocosms and mathematical simulations. The adaptation of life cycles to diurnal and seasonal variation in environmental conditions is studied for its possible role in the response of oceanic systems and carbon fluxes to climatic change. The extensive research at sea is only possible in co-operation with other NIOZ departments and national and international groups of scientists. The present work is part of JGOFS, GLOBEC and INP.

1. PELAGIC SYSTEMS IN THE TEMPERATE ZONE

Phaeocystis spring bloom: DMS and DMSP

During the spring bloom in the Marsdiep (13 March-29 June) the DMS (dimethylsulphide) and DMSP (dimethylsulphoniopropionate) concentrations in the water column were monitored twice a week. DMS concentrations (40 nM) were highest during the initial exponential growth phase of *Phaeocystis* colonies. *Phaeocystis* is a well-known DMSP producer. In the first part of the bloom in April DMS peaks occurred just before *Phaeocystis* peaks. This is not in accordance with the generally assumed mechanism of DMS-release, in which the DMS peak comes shortly after the peak in the DMSP-containing alga. Laboratory experiments were conducted to estimate the bacterial degradation of DMS during different stages of the spring algal blooms in the Marsdiep. Mass deposition of the DMSP-containing alga *Emiliania huxleyi* in sediment microcosms showed that within days DMS is released from the algae. This process was delayed and less complete when algae were kept in suspension. This may imply that sediments are a source of DMS after sedimentation of DMSP-containing algae.

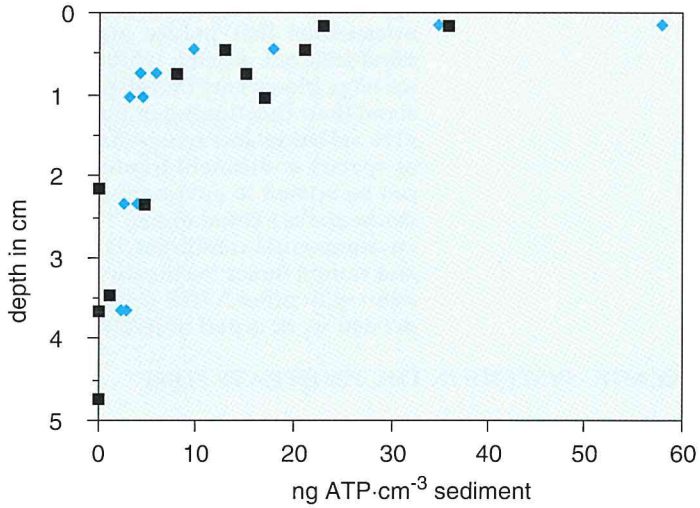
A detailed model of the DMS production in the southern North Sea has been developed, in close co-operation with the partners in the European Community DMS project. All major production and conversion flows are incorporated in the model, which has been coupled with the FyFy model. Results show a close correlation with field data, with highest concentrations and atmospheric exchange in the coastal area. Furthermore, the model indicates the importance of the only recently discovered process of phytoplankton lyase conversion of DMSP. This process improves the description of the spring peak in DMS production.

Pelagic-benthic coupling

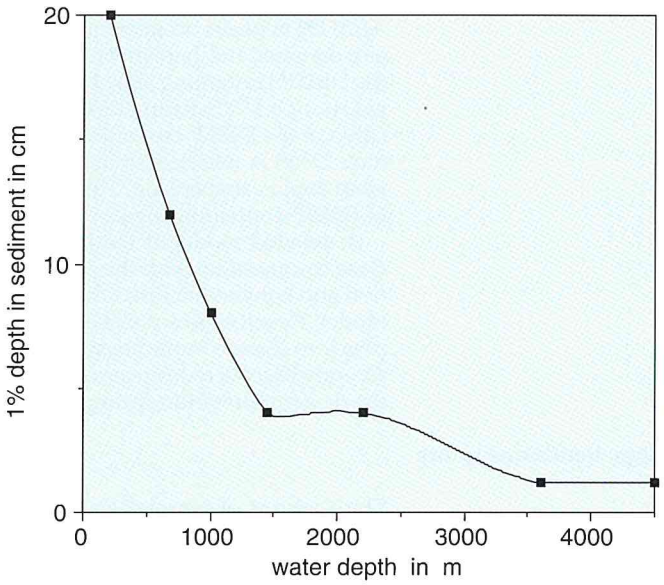
The analyses of samples and processing of data collected during the STED-cruise to the Oyster Grounds, North Sea in July 1994, proceeded steadily. Short-term dynamics in the water column with respect to mixing events, induced by variation in wind velocities, wave height and cold fronts, were almost absent during the STED-cruise. Only one minor mixing event occurred during the cruise, which enhanced the phytopigment concentration in the surface mixed layer (SML) at 5 m depth. The event appeared to have no influence on the pigment concentrations in the bottom mixed layer (BML) under the thermocline. The chlorophyll *a* concentration in the BML was three to eight times higher than in the SML. Variation in sedimentation / resuspension of organic matter and phytopigments partly related to the tidal current velocities and direction (advective transport) was not reflected by significant variation in benthic bacterial production and abundance in the 3 mm top layer of the sediment. The bacterial production and abundance did not significantly vary nor change during the STED-cruise. The daily input of organic matter estimated on the basis of the sediment trap data and the conversion of chlorophyll *a* to carbon (*25) ranged from 3 to 29 $mgC \cdot m^{-2} \cdot d^{-1}$, but was usually quite constant (13 $mgC \cdot m^{-2} \cdot d^{-1}$). This was only a minor fraction of the chlorophyll *a* in the BML, but it may provide a considerable fraction (*ca* 25%) of the C demand of bacteria in surface sediments.

Supply, quality and utilization of organic matter in benthic communities

—*Microbial biomass and activity in the Celtic Sea.* To obtain a better understanding of the feeding of the deep-sea biota we studied distribution of microbial biomass (as ATP) in the water column and bottom sediments. Microbial biomass in deep-sea sediments will be related to vertical and horizontal input of organic material. During the August/September OMEX cruise in the Celtic Sea we sampled along two transects from the continental slope to the deep sea (Goban Spur and Porcupine Bank). First results indicate a rapid decrease with depth in the sediment and a decrease in depth penetration with increase in water depth: 1% of the surface value of ATP is found at 20 cm at the shelf margin and a 2 cm at 4000 m depth.



Vertical distribution of ATP in sediment from two stations at 2200 m water depth.



The 1% depth of ATP-biomass over the Goban Spur transect.

—*Bacteria as nutrient consumers.* In post-bloom nutrient-limited conditions bacteria can act as N and P consumers. We tested this during the OMEX expedition. Experiments with water from the surface layer showed that addition of organic C immediately increases the uptake of N and P and the bacterial numbers. The strongest effect was seen in the experiments with simultaneous N, P and C addition in the unfiltered and prefiltered samples (over 1 µm filters). This proves that there is a shortage of degradable organic carbon and that the bacteria consume N and P. Sometimes a small increase in ammonia was seen at the end of the experiment when nitrate and phosphate had been consumed. The samples with enrichment only in C show a small decrease in the small amount of N and P. This means that bacteria have a high affinity for N and P and that they can consume even the lowest concentrations. Bacteria are a sink for N and P if organic C is available.

In bioassay experiments with deep-sea fluff as organic C no significant increase of N and P consumption could be observed.

Effects of nutrient concentrations and recycling on the structure and productivity of the marine ecosystem

The research on natural mortality processes in phytoplankton demonstrated substrate-induced death of *Ditylum brightwellii* after a nitrogen pulse to N-limited cultures. Recovery responses were studied in relation to pulse doses and physiological condition of this alga. Another important natural loss factor is viral infection. Although this has been identified as a potentially regulating factor in natural assemblages, not a single example has ever been described. During an *Emiliania huxleyi* bloom near the Shetland Islands in July 1993, viral infections were observed in up to 60% of the *E. huxleyi* population. Measured autolysis rates were related to infection frequency, and bacterial production was correlated with the autolysis rate of phytoplankton.

The mucoid layer of *Phaeocystis* colonies was studied as a possible barrier to the diffusion of dissolved nutrients. Together with E. Epping and H. Ploug (MPI, Bremen), a mathematical diffusion model was constructed. Oxygen profiles in the colonies, measured with an oxygen micro-electrode, were used to calibrate the model.

The data on phytoplankton from the Shetland cruises of 1994 have been worked out in greater detail. Size differential (*i.e.* smaller and larger than 5 µm) uptake of ^{15}N-labelled compounds (ammonium, urea, nitrate) and ^{14}C (bicarbonate) by phytoplankton was measured along a transect from the Shetland Islands to the Dogger Bank (North Sea) in early spring 1994. A non-stratified water column and high nutrient levels throughout the transect indicated that phytoplankton growth was controlled by light. It had been postulated that under such light-limiting growth conditions smaller algae grow faster than larger species. Ammonium was low (< 0.15 µM) while nitrate ranged between 11 µM at the Shetlands and 0.3 µM at the Dogger Bank. Urea concentrations were below 0.1 µM. At the shallowest stations of the transect (the Dogger Bank) a phytoplankton bloom was found. The 15N incubations indicated that nitrate was the major N source for the phytoplankton in both size fractions. Specific nitrogen and carbon uptake rates were found in the order of $0.3 \cdot d^{-1}$ for the <5 µm fraction and $0.1 \cdot d^{-1}$ for the >5 µm fraction. Average specific nitrogen and carbon uptake rates for the total population were in the order of $0.2 \cdot d^{-1}$ indicating limiting growth conditions. Assuming that specific uptake rates for N and C are indicative of the growth rate, it was concluded that under light-limiting growth conditions smaller algae grow faster than the larger ones. Despite their lower growth rate, algae larger than 5 µm constituted the major part of the spring bloom at the Dogger Bank. Most likely, their dominance was due to grazing control of small phytoplankton by microzooplankton.

Mesozooplankton samples revealed that in both Shetland cruises in March and August of 1994 the total zooplankton biomass tended to decline gradually from the Dogger Bank to the Shetland area (55°N to 61°N). But there was a secondary rise north of 59°N. During summer, additional peaks were found at 57°N and 59°N. On average the summer biomass was a factor of four higher than in spring. These fluctuations do not coincide with changes in species composition. North of 56°N, two copepod species dominated zooplankton biomass in both seasons: *Calanus finmarchicus* (about 70% of copepod biomass) and *Oithona similis* (about 20%). South of 56°N neritic copepods (*Temora longicornis)* increased substantially, but did not match the lower masses of the oceanic species. The bimodal distribution may reflect food conditions as indicated by the chlorophyll maxima in the surface layer, which were observed south of 57°N in March and north of 60°N in August. Copepods formed more than 80% of mesozooplankton biomass at almost all stations.

An important part of the activities on modelling ecosystems was carried out in the framework of the ERSEM project. In this project six institutes collaborate to construct a model of the North Sea. This model aims to describe in a generic way all important processes of a shelf sea ecosystem. The task of NIOZ is especially the modelling of nutrient fluxes in the sediment, in the water/sediment interface and in the water column. The first task is the further development of the benthic nutrient model. This submodel determines the vertical fluxes from simulated gradients in the sediment and at the sediment/water interface. The elaborated submodel can now be applied for the whole range of environmental conditions (oligotrophic-eutrophic, oxic-anoxic), as well as for long-term simulations. Attention focuses on the denitrification and phosphate adsorption, which control the definitive removal of nutrients. The second task is the coupling of ERSEM submodels of biological and chemical processes with a one-dimensional stratification submodel. With this set-up we can now study in a very detailed way the interaction between the transport processes as controlled by meteorological circumstances, nutrients, phytoplankton and its grazers.

Influence of UV-b radiation on picoplankton

In January 1995 research was started on the influence of UV-b radiation on picophytoplankton in co-operation with the University of Groningen (RUG). Cultures of *Synechococcus* and *Micromonas pusilla* were grown in quartz curvettes and irratiated with different doses of UV-b radiation (0-4000 $J \cdot m^{-2} \cdot d^{-1}$, weighted with the action spectrum of Setlow, normalized at 300 nm). Cells were counted using a Coulter Counter. The growth rate decreased only at high UV-b doses. The NIOZ flow cytometers were used in combination with an antibody against a DNA-photoproduct (thymine dimer) to determine possible DNA damage in whole cells. Furthermore, a method was tested to isolate DNA from several cultures. This procedure can be used in future experiments to quantify UV-induced thymine dimers.

Contributors: *A.J. Van den Berg* (modelling), *J.D.L. Van Bleijswijk* (phytoplankton), *P. Boelen* UV-b radiation), *C. Brussaard* (algal natural mortality), *E.T. Buitenhuis* (carbon fluxes), *F.C. Van Duyl* (microbial ecology), *H.G. Fransz* (zooplankton, modelling), *S.R. Gonzalez* (zooplankton/sedimentation), *R. Kempers* (phytoplankton), *A.J. Kop* (algae, DMS, DMSP), *G.W. Kraay* (pigments), *B.R. Kuipers* (microzooplankton), *W.E. Lewis* (DMS, DMSP), *A. Noordeloos* (phytoplankton ecophysiology), *G.J. Van Noort* (microbial ecology), *R. Osinga* (microbial ecology), *E. Pauptit* (microbial ecology), *R. Riegman* (phytoplankton ecophysiology), *P. Ruardij* (modelling), *W. Stolte* (phytoplankton nutrient uptake kinetics), *M.J.W. Veldhuis* (phytoplankton), *J.H. Vosjan* (microbial ecology), *P. Van der Wal* (phytoplankton), *H.J. Witte* (microzooplankton).

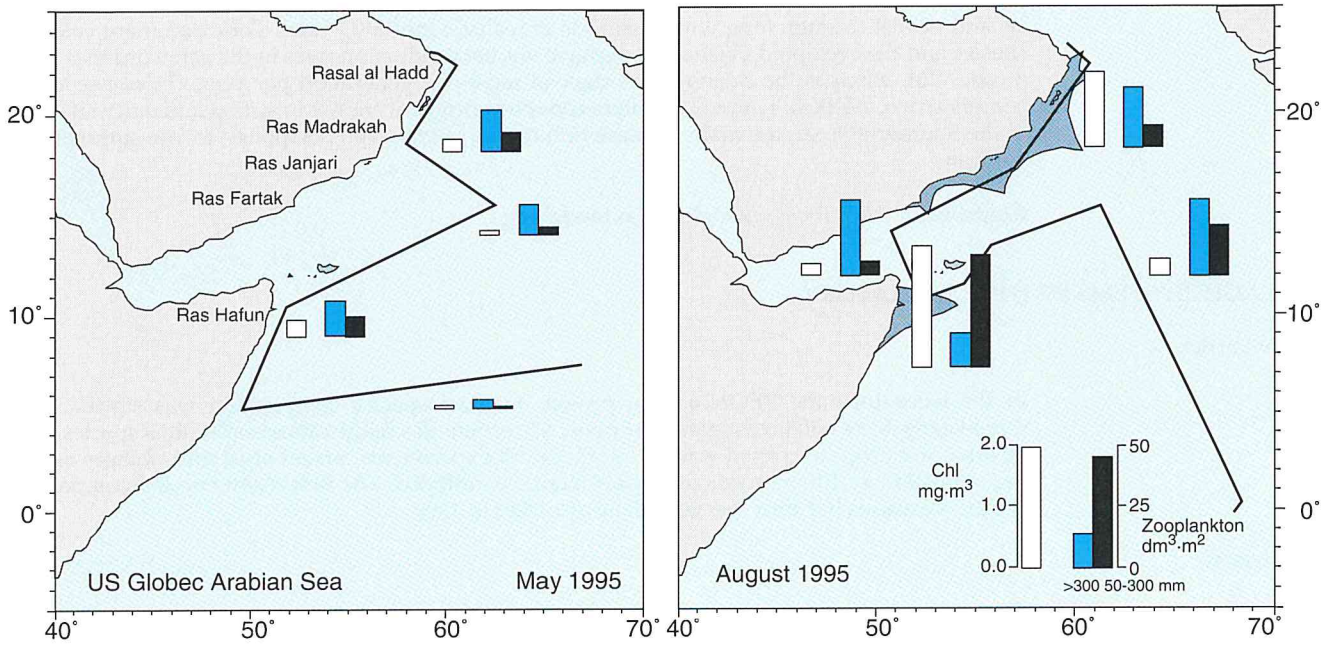
2. PELAGIC SYSTEMS IN TROPICAL WATERS

NIOP

The studies of the seasonal upwelling near Somalia during the Netherlands Indian Ocean Programme (NIOP) 1992-1993 led to an invitation to join the GLOBEC Arabian Sea cruises by the NOAA RV 'Malcolm Baldridge' during May and August 1995. The American programme mainly comprised extensive collections of zooplankton and micronekton by MOCNESS (multiple nets with mesh sizes of 150 µm and 3 mm) tows down to 1500 m depth. In both these cruises three Dutch scientists participated, supported by the Netherlands Geosciences Foundation (GOA). Plankton was collected continuously by a pump system, to measure the $^{13}C/^{12}C$ and $^{18}O/^{16}O$ ratios in foraminifers for comparison with similar measurements in water samples from pump and CTD rosette (F.J.C. Peeters and A.T.C. Broerse, Free University Amsterdam). Profiles down to depths of 2000 m were obtained for oxygen, POC/DOC, bacterial numbers and production, to study the probable occurrence of an increased bacterial activity at the lower interface of the oxygen minimum zone (C.J. Wiebinga, Department of Marine Chemistry and Geology). Phytoplankton sampling in the upper 100 m comprised chlorophyll pigment and species composition, and zooplankton was collected by hauls to the surface with a 50 µm net. Displacement volumes of the catches were measured for the fractions below and above 300 µm, with the latter data for comparison with previous studies in the NW Indian Ocean. During May, waters with a typical tropical structure predominated, with Sea Surface Temperature (SST) 30°C. In the mixed layer chlorophyll concentrations were only 0.05 to 0.1 $mg \cdot m^{-3}$, and in the Deep Chlorophyll Maximum (DCM) (at 60-100 m depth) circa 0.3 $mg \cdot m^{-3}$. Displacement volumes of the net catches were very low, 4 $cm^3 \cdot m^{-2}$ for the >300 µm and 1 $cm^3 \cdot m^{-2}$ for the 50 to 300 µm fraction, except for stations in the central Arabian Sea (12 and 3 $cm^3 \cdot m^{-2}$, resp. for both size fractions). Off Somalia (Ras Hafun) and off Oman (Ras Madrakah-Ras al Hadd), the first signs of upwelling were observed, with isotherms sloping up towards the coast, a 1 or 2°C lower SST and chlorophyll concentrations in the mixed layer ranging from 0.2 to 1.0. Displacement volumes here were 17 and 8 $cm^3 \cdot m^{-2}$, resp. for both size fractions. During August, at the height of the upwelling, SSTs had dropped to 21 to 27°C, a DCM was absent and mean upper layer chlorophyll was over 1 $mg \cdot m^{-3}$. Mean overall displacement volumes were 25 and 20 $cm^3 \cdot m^{-2}$. This suggests that during the upwelling season a much larger part of the zooplankton is in the small fraction than during non-upwelling conditions. However, as the small fraction often contained much phytoplankton, microscopical analysis is needed to determine the zooplankton density pattern properly. Highest values (>30 $cm^3 \cdot m^{-2}$) for the larger fraction were found in areas with relatively low chlorophyll, suggesting a large grazing pressure during post-bloom conditions. Displacement volumes for >300 µm were lower at sites with massive diatom blooms, off Oman (Ras Janjari) and off Somalia (Ras Hafun).

Previous collections by 300 µm nets in the western Arabian Sea showed no significant difference in zooplankton biomass between the summer upwelling (SW monsoon) and the more oligotrophic winter season (NE monsoon), an enigma called 'the Arabian Sea Paradox'. However, recent analysis of 200 µm catches by RV 'Tyro' in 1992-1993 revealed that zooplankton density and biomass differed by a factor of four between the monsoons. The preliminary results from the catches by RV 'Baldridge' described above also indicate that seasonality in zooplankton biomass in this area is more pronounced than thought earlier.

A proposal for a field programme in the tropical Atlantic in summer 1996 was approved by GOA. The central question concerns the structure and the dynamics of the Deep Chlorophyll Maximum at a depth of 100 to 150 m. This layer, dominated by picophytoplankton (< 2 µm in diameter), is present in all oligotrophic waters and seems to be remarkably constant, despite high activity of photosynthetic and heterotropic components. In collaboration with various other groups at NIOZ and in Groningen, as well as with experts on taxonomy and genetics of phytoplankton in Roscoff (France) and Eilat (Israel), a variety of new techniques will be employed to characterize the organisms and flows within the Deep Chlorophyll Maximum. The ultimate goal is to estimate the role of the DCM in the carbon dynamics of tropical waters, and to predict its reaction to global environmental changes.



Cruise tracks by NOAA RV 'Malclom Baldridge' for the US GLOBEC Arabian Sea Programme; first leg (left) Colombo-Muscat 27 April-24 May, and second leg (right) Muscat-Diego Garcia 31 July-27 August 1995. Bars indicate chlorophyll and zooplankton concentrations at stations along the tracks.

Tropical coastal ecology

The fieldwork running since January 1994 at CARMABI, Curaçao, Netherlands Antilles, on seasonal variations in structure and activities of the pelagic small food web over the coral reef was terminated in February. The seasonal pattern was influenced by upwelling events in May-July and by run-off from the island and enhanced water exchange with inland bays during occasional rains from August to January. The polluted stations (Anna Bay and Avila) were characterized by enhanced microbial activities in comparison with activities at unpolluted reef stations and the ocean. The linkage of the pelagic microbial food web to the reef benthos received further attention. Research was conducted on the differentiation in coral reef water layers with respect to microbial variables, DOC and POC during a three-week expedition in January. Structure and functioning of the small food web were compared between surface water (2 m), bottom water between corals (6-9 m), in coral cavities and in the coral surface microlayer. Mucus produced by stony corals was found to stimulate the bacterial production. With grazer-free seawater cultures of the different water types it was demonstrated that water collected on the coral surface microlayer enhanced bacterial production compared to bacterial production in coral cavity water and surface water. Apparently cavity water contained less labile substrate for bacterial uptake than surface and coral surface microlayer water. Moreover, preliminary data show that densities of bacteria and nanoflagellates were on average lower in cavities than outside cavities, which might point to a significant uptake of particles by filter-feeding organisms in cavities. Depth profiles from 2 to 8 m depth in the adjacent ocean water showed a significant increase in bacterial protein production with depth. Preliminary results suggest that UV-b might play an important and underestimated role in the functioning of the small food web in tropical reef waters.

Contributors: *M.A. Baars* (zooplankton, ecosystem dynamics), *F.C. Van Duyl* (microbial ecology), *G.J. Gast* (microbial ecology), *S.R. Gonzalez* (zooplankton), *G.W. Kraay* (phytoplankton), *S.S. Oosterhuis* (zooplankton), *M.J.W. Veldhuis* (phytoplankton).

3. PELAGIC SYSTEMS IN POLAR SEAS

Since May 1994 population models of the Antarctic copepod species were constructed in co-operation with Dr. F. Carlotti of CNRS on the base of a literature study of their ecophysiological characteristics. Meetings were organized at Villefranche in May and on Texel in July 1995. The aim is to study seasonal development and production as a function of temperature and food relationships, and to construct zooplankton submodels for Antarctic ecosystem models. The resulting

population models indicate that all species can endure extremely low temperatures and food levels and persist through long winter periods at realistic mortality rates. Four dominant calanoid species and the cyclopoid *Oithona similis* have annual production rates in the same order of magnitude. But, whereas the calanoids produce at most one generation per year, *Oithona* seems to complete two. While in temperate waters copepods produce mainly in spring and early summer, in the Southern Ocean the main increase of biomass seems to be postponed to late summer and autumn.

Contributor: *H.G. Fransz* (zooplankton modelling).

4. PELAGIC SYSTEMS IN THE LABORATORY

BEON-garden

In the laboratory, the BEON-garden project on algal species composition was started. This three-year project will investigate the impact of nutrient discharge ratios on the algal species composition in European coastal waters. In laboratory experiments, mixed algal assemblages are being cultivated at different sets of environmental conditions. The first results on the competitive ability of various harmful species will be available in 1996.

Mesocosms

Mesocosms were used for tests on the effects of nutrient enrichment, necessary for the selection of appropriate measuring methods and sampling frequency for the eutrophication experiments. Considerable differences were observed between the development of systems with high nutrient content from the start as originally planned, and those receiving gradual input until the same content was reached. The first systems developed blooms followed by massive sedimentation within a short time, the latter showed continued high biomass of suspended algae and micrograzers. Future experiments will attempt to explain this difference.

Microzooplankton grazing experiments were carried out to compare the results of the Landry & Hasset dilution method with a number of other possible ways to separate the factors growth and grazing-mortality in grazing measurements. Chemical inhibition of grazer activity without affecting the algae was unsuccessful; inhibition of algal growth for 24-h periods by short exposure to extremely high light irradiation appeared more promising and will be explored as a possible alternative to the laborious dilution series. The feasibility is being investigated of measuring grazing by microzooplankton in natural waters in daylight periods when, according to previous flow-cytometrical determination of DNA content per cell, algal division rates are close to zero.

Population dynamics and bio-energetics in experimental pelagic ecosystems

The experimental research on zooplankton investigates the significance of environmental variables for the ecophysiology of marine zooplankton under controlled conditions in the laboratory. Key species of copepods are used to determine their contribution to secondary productivity and to the control of algal blooms. The basis for these experiments are stock cultures of *Temora longicornis* and *Pseudocalanus elongatus* maintained in the laboratory for many generations. High numbers of copepods produced in these cultures were used to stock experimental mesocosms, to test the functioning of this large-scale system. The copepod cultures were also used for a study of S. Peulvé (Université de Paris) and V. Grossi (Centre d'Oceanologie de Marseille) on algal pigment and lipid degradation in copepod faecal pellets during sedimentation.

Pilot experiments were performed in small bottles rotating slowly in a roller-apparatus, showing that such a set-up is quite suitable to grow copepods at optimum rates, comparable to the rates observed in large volume stock cultures. Weight appeared to be a more sensitive measure of growth than development rate, since even in filtered water without food copepods appear to develop for some time, relying upon energy reserves. These experiments levelled the path for current grazing and growth experiments with *Temora longicornis* and *Pseudocalanus elongatus* using algae of different food quality.

The quality of the algae was studied to test for differences in biochemical composition, which seems to be a major factor explaining the trophic role and productivity of zooplankton in the sea. On the one hand, this is done by using different species of algae that are of similar size but vary in their taxonomic origin. On the other hand, within-species differences in biochemical composition are studied by manipulation of the nutrient composition and flow-rate of the culture medium. Altogether, at present 10 different continuous cultures are running simultaneously. Since microzooplankton is an important alternative food source for copepods, the influence of algal quality on microzooplankton and, via these, on copepod development will be studied as well.

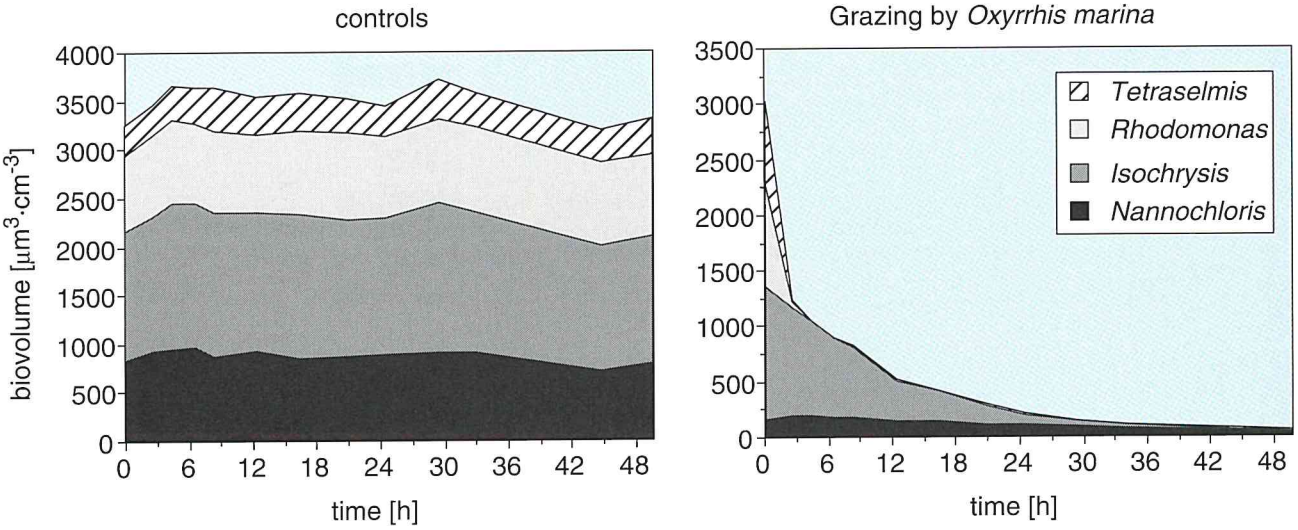
The possibility of using the Image Analysis System for semi-automatic quantification of autotrophic and heterotrophic micro-organisms was studied further. For bacteria a routine of J.

Bloem (RUG) was adapted for semi-automatic measuring and counting of bacteria in pelagic samples from the North Sea. The system was also used to estimate the cell volume of nanoflagellates accurately, which is not possible with electronic equipment such as the flow-cytometer or Elzone particle counter. The cell volume estimates of six species of flagellates were used to set up grazing experiments with microzooplankton.

Selective grazing on nanophytoplankton

Selective grazing on nanophytoplankton by the heterotrophic dinoflagellate *Oxyrrhis marina* was investigated by means of laboratory incubation experiments. To test for size selectivity, *O. marina* was offered a food mixture of algae of different sizes: *Nannochloris* sp. (2 µm Equivalent Spherical Diameter), *Isochrysis galbana* (5 µm ESD, *Rhodomonas* sp. (8 µm ESD) and *Tetraselmis* sp. (10 µm ESD). *O. marina* grazed selectively on the larger algae (ESD 7µm), and also selected for the larger cells within each species.

To test for possible selective grazing on *Emiliania huxleyi*, *O. marina* was offered mixtures of equal concentrations of the (approximately) similarly sized algae *E. huxleyi* and *Isochrysis galbana*. In these mixtures, *O. marina* preferred calcified *E. huxleyi* cells to non-calcified *E. huxleyi* cells and *I. galbana*. This result can also be interpreted in terms of size-selective grazing, since calcified *E. huxleyi* are bigger than both non-calcified *E. huxleyi* and *I. galbana* cells. A daily rhythm in *E. huxleyi* cell size was found in the controls, but it was suppressed in the presence of *O. marina*. This may indicate a preference of *O. marina* for the metabolically active fraction of their algal food.



Mean algal biovolume concentrations over 48-h incubations with and without (controls) and with *Oxyrrhis marina* grazing on *Nannochloris* sp. (2 µm), *Isochrysis galbana* (5 µm), *Rhodomonas* sp. (8 µm) and *Tetraselmis* sp. (10 µm).

Contributors: *S.R. Gonzalez* (zooplankton), *F.C. Hansen* (microzooplankton), *W.C.M. Klein Breteler* (zooplankton ecophysiology), *B.R. Kuipers* (microzooplankton), *A. Noordeloos* (phytoplankton ecophysiology), *G. Van Noort* (microbiology), *R. Riegman* (phytoplankton ecophysiology), *S. Scheffers* (microzooplankton grazing), *N. Schogt* (zooplankton ecophysiology), *H.J. Witte* (microzooplankton).

沿岸生態系の解析 II

干潟の生態系モデル

Simulation and Analysis of the Ems Estuary

編集・J.バレッタ & P.ルアルディ
訳・中田喜三郎

Tidal Flat Estuaries

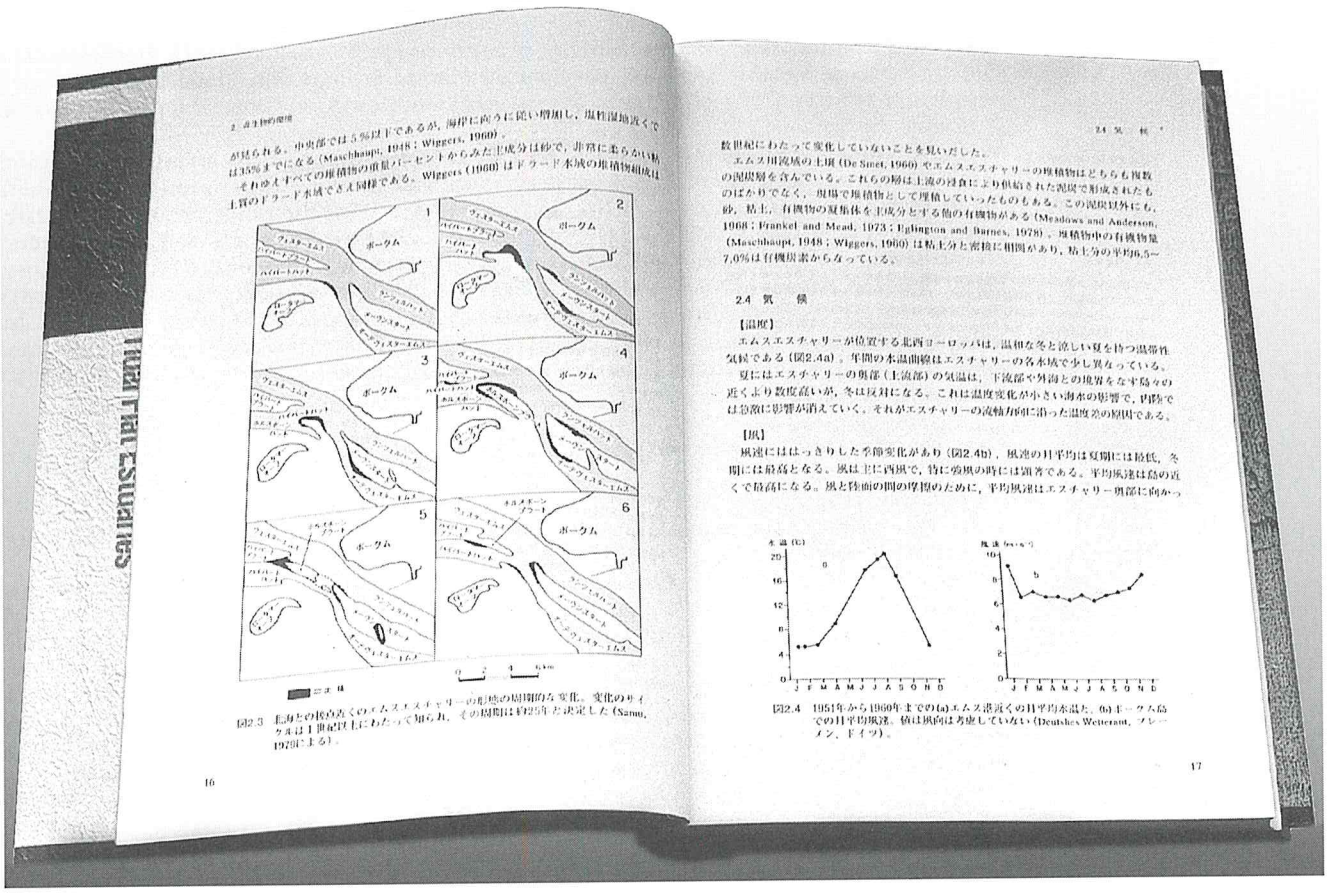


図2.3 私海との境のあるエムスエスチャリーの形態の周期的な変化．変化のサイクルは1世紀以上にわたって知られ，その周期は約25年と決定した（Samu, 1970による）．

図2.4 1951年から1960年までの(a)エムス港近くの日平均水温と，(b)ボークム島での日平均風速．値は風向は考慮していない（Deutsches Wetterant，クレーメン，ドイツ）．

A note from the translator Kisaburo Nakata:

The book Tidal Flat Estuaries: Simulation and Analysis of the Ems Estuary by J. Baretta and P. Ruardij (Ecological Studies vol. 71, Springer-Verlag, Berlin) has been translated into Japanese. It is one of two books selected by the Japan Fisheries Resources Conservation to serve as basic literature needed for scientists involved in a project on the evaluation of purification potential of tidal flats in eutrophicated bays (contract Fisheries Agency of Japan). This book was chosen because it gives a clear presentation and analysis of the wide range of parameters that need to be included in a model of an ecosystem. It has greatly added to the success of the project for which it was translated, but is also expected to be useful for graduate students and consultancies involved in land reclamation projects and environmental assessment.

DEPARTMENT OF MARINE ECOLOGY

The new Department of Marine Ecology consists of (parts of) the former Departments of Coastal Systems, Benthic Systems and Applied Marine Ecology. The Department studies (1) population ecology, (2) structure and dynamics of benthic systems and (3) long-term changes in marine ecosystems.

Marine ecosystems, and especially the benthic communities, harbour an astonishing biodiversity, and numerous complex biological, physical and (geo)chemical processes underlie the maintenance and functioning of its living components. With the political urge for possible protection of biodiversity and the growing concern about the effects of global change, there is an increasing need for basic knowledge on the structure and functioning of marine ecosystems. The Department of Marine Ecology focuses on the short- and long-term development of marine ecosystems in shallow and deeper seas both at the species and community level. In a multidisciplinary approach, in close co-operation with other NIOZ departments and within many national and international research projects, the natural and man-induced variability of the marine ecosystem is investigated.

The research projects are grouped into three major themes.

1. Population ecology
This theme clusters population studies on individual benthos, fish and bird species which play an important role in the Wadden Sea and North Sea ecosystem.

Species studied are: the amphipods *Corophium volutator* and *C. arenarium*, the lugworm *Arenicola marina*, the bivalves *Cerastoderma edule*, *Macoma balthica*, *Mya arenaria* and *Mytilus edulis*, shrimps, the flatfishes plaice, flounder and dab, and wader birds, particularly the knot *Calidris canutus*.

Present and past interrelationships between key species, and relationships with environmental parameters, are also being studied. Because climate change may result in changing mean winter or summer temperatures influencing population dynamics, major topics are the reproductive success of bivalves and the brood success of flatfish under different temperature regimes.

This theme also includes applied research on populations, *e.g.* physiological requirements in tiger shrimp culture and the effects of offshore mining activities on the surrounding macrobenthos.

2. Structure and dynamics of benthic ecosystems
This theme deals with the composition and structural properties of selected benthic communities in terms of biodiversity, size and age spectra, numerical density, biomass, and supply and utilization of organic matter.

Comparative studies in areas that offer a wide range of extremes (*e.g.* shallow-deep, high-low altitude, soft-hard bottom, oligotrophic-eutrophic) will increase our understanding of the structure of benthic ecosystems, their maintenance/resilience capacities and long-term alterations. Major research areas are the North Sea, continental slopes, and coral reef environments. To improve benthic observation and measuring methods further the construction of a second generation of an Autonomous Lander for Biological Experimentation (ALBEX) has started.

3. Long-term studies of marine ecosystems
NIOZ has a solid tradition concerning long-term time series collected in the western Wadden Sea. Data on salinity and temperature in the Marsdiep inlet go back to 1861, while data on phytoplankton in the Marsdiep have been collected since 1968, zoobenthos on the Balgzand since 1971, intertidal fish trap catches since 1960, and breeding success of Eiderducks on Vlieland since 1962. These series reveal a wealth of information on the long-term functioning of the marine ecosystem. Analysis of these series to establish relationships of observed changes with changing natural and man-induced variables is the major topic of this theme.

Special attention is paid to the effect of fisheries on the benthic species and ecosystem. The Dutch beamtrawl fisheries rake every km^2 of the bottom of the North Sea, on average one to two times per year! The long-term effects of this activity are unclear and form the subject of several international research projects.

1. POPULATION ECOLOGY

Autecological studies of key species

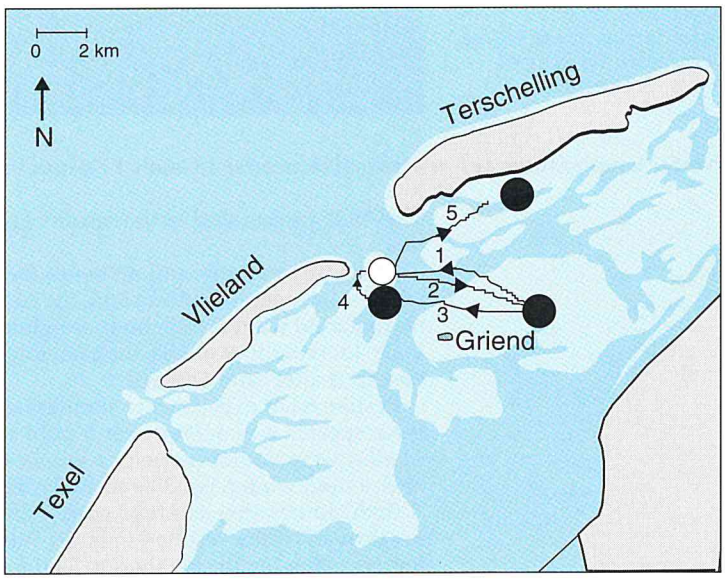
—*Macrofauna.* The amphipods *Corophium volutator* (Pallas) and *C. arenarium* Crawford can generally be found in high densities in the higher parts of the tidal flats of the Wadden Sea, the former species in muddy areas and the latter where the sediment is sandy. Their upper limits are close to the local level of high water at neap tide. These upper limits are set by the frequency or duration

of inundation, as they shift shorewards during periods of higher-than-average water levels (caused by prevailing westerly winds) and downwards during periods of lower-than-average water levels (by prevailing easterly winds). In contrast, the lower limits of these species do not show such a strict relationship with water levels. They coincide with the upper levels of high densities of lugworms (*Arenicola marina*) and/or cockles (*Cerastoderma edule*). The intertidal height of these levels varies from place to place (in connection with sediment composition). By their bioturbative activities, these interacting species destroy the tiny burrows of *Corophium* and drive them away. Thus, interactions with other species (and not abiotic factors such as inundation) set the lower limits of *Corophium* spp. In the intertidal, it is a generally occurring phenomenon that upper limits of marine species are set by harsh environmental conditions and lower limits by interrelations with other species. So far, however, nearly all examples refer to rocky coasts.

In the early 1980s, the American razor clam *Ensis directus* (Conrad, 1843) invaded Europe and spread rapidly over the Wadden Sea. Since 1982 its density was determined twice annually on Balgzand as part of the long-term macrozoobenthos sampling programme. Though settlement took place every year, a strong year class developed only in 1991. Early bottom stages were observed over most of Balgzand, but successful development to adults only occurred in the most offshore part, where clean sands prevail and the tidal flats are hardly ever drained at low tide. Growth rates were maximal in these areas and exceeded published records from elsewhere in the Wadden Sea and North Sea. The habitat chosen by *E. directus* is poorly occupied by other species, probably because it is frequently exposed to strong currents and high waves. The strong 1991 year class dominated the fauna in the area during 1992 and 1993, but suddenly disappeared in the 1993/94 winter through unknown causes.

—*Fish.* In flatfish, recruitment appears to be related to the size of the nursery. This so-called 'nursery-size' hypothesis has been studied in more detail for a number of flatfish species. For plaice, *Pleuronectes platessa*, a detailed analysis has been made of the growth and mortality during the first year of life. Unexpectedly, preliminary results show no differences in growth and mortality between estuarine and open sea nurseries. These findings may be biased by size-selective mortality. The consequence of size-selective predation is that all growth estimates based on increases in length of the population will be biased. Although the bias does not seem to be serious, independent validation of the growth estimates is required by means of otolith microstructure analysis. Extensive analysis of data on juvenile dab in the North Sea indicates that in this species year-class strength is also established in the juvenile phase. However, compared with plaice, year-class strength determination appears to be later in dab: not before the second year of life. This may be related to the fact that plaice has coastal nursery areas and dab offshore nursery areas.

—*Birds: Movements of individual Knots in relation to intertidal food resources and supratidal roost sites.* In late July 1995, fourteen of the 50 Knots captured near their high tide roost on Richel in the western Wadden Sea were radiomarked with transmitters of 1.5 g. Most of them probably belonged to the *canutus*-subspecies, and were on their way from the breeding grounds in Siberia to the wintering grounds in West Africa. We have intensely followed the movements of these fourteen individuals, by regular observations near Richel, from the island of Griend and at several other localities in the western Wadden Sea. In this way we were able to document diurnal and long-



The movements of a radio-marked Knot. In the morning of 1 August 1995 the bird is feeding on the mudflats near Griend; around noon it flies to the roost on Richel (1). After high tide it flies back east (2) and is twice recorded feeding near Griend. In the second half of this low tide period it is recorded feeding on the mudflats south of Richel (3). During that night it roosts on Richel (4), but the next morning it is feeding south of Terschelling (5). The grey dot indicates the Knot's roost on Richel; black dots indicate the three feeding sites.

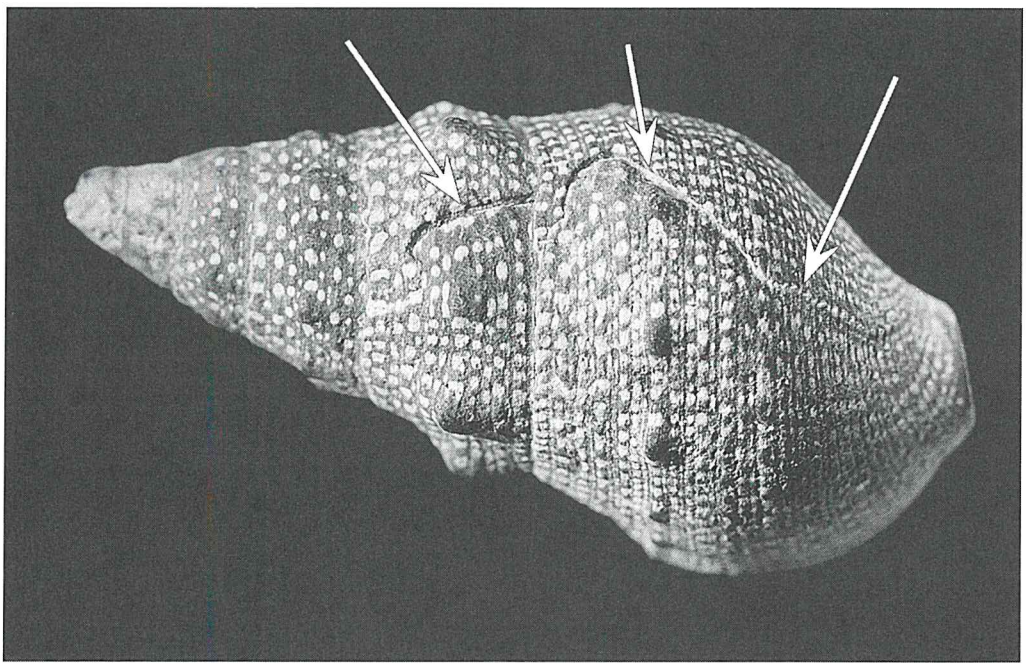
er-term changes in feeding area, individual time budgets (*e.g.* time on the high tide roost during day and night), regular commutes between Richel and the Frisian coast (at least 25 km one-way) and temporary changes in food choice. About 11 birds left the Wadden Sea in the third week of August, but two birds stayed behind, being registered even five weeks after marking. We expect to correlate the movements of individual birds and flocks with their benthic food supplies.

Palaeobiology

Predation influences the evolution of prey. Particularly Vermeij has argued that predators have been responsible for trends in shell morphology of gastropods and he suggested an 'arms race' between aperture-breaking crabs and (warm water) gastropods. Unsuccessful attacks of aperture-breaking (= lip-peeling) crab predators leave characteristic repair scars on the gastropod shell. High frequency of unsuccessful predation indicates that predators exert a strong selection pressure and that prey successfully resists most attacks.

In a recent environment (Bahia la Choya, northern Gulf of California) repair frequency in four gastropod species showed large variation between species (7-88%). Spatial variation of repair frequency was also large (27-65% in *Cerithidea albonodosa*). These interspecific and spatial variations are as large as the temporal trend in repair frequency observed by Vermeij. This indicates that for a reliable repair frequency figure for one locality or one geological period, different species and different (paleo)environments have to be sampled.

Part of the spatial (micro)habitat variation in the living population will, however, be obliterated in the dead shell assemblage by horizontal movements of empty shells by physical (waves and currents) and biological (hermit crabs, predators such as birds) agents. For these smoothing processes the term 'habitat averaging' is suggested.



Repair scars on *Cerithium stercusmuscarum* from Bahia la Choya caused by unsuccessful crab attack. Photo: H. Hobbelink.

Winter temperatures and reproductive success in some bivalves in the Dutch Wadden Sea

This NOP project studies the causes of recruitment failure in Wadden Sea bivalves after mild winters.

Winter temperature can influence the condition (*i.e.* body weight at a given length) of bivalves such as the mussel *Mytilus edulis*, the cockle *Cerastoderma edule* and the Baltic clam *Macoma balthica*. During mild winters their body weights generally diminish faster than during cold winters resulting in less energy available for gametogenesis. This would explain the recruitment failure so often observed after mild winters.

Results from experiments simulating winter in the laboratory show that the condition of the three species was poorer after a mild winter than after a cold winter. Egg sizes of *Macoma* and *Mytilus* were not influenced by winter temperature. In the cockle, eggs were on average smaller after a mild winter. Food availability did not affect egg size.

Both temperature and food supply affected egg numbers in *M. balthica* and *C. edule*. Lower temperature in winter resulted in larger numbers of eggs in spring and so did longer submersion intervals (allowing the bivalves to feed for longer daily periods).

Egg size is determined during gametogenesis. *M. balthica* morphologically finishes gametogenesis in late autumn, and therefore only the numbers and not size of eggs can be affected by winter conditions. *C. edule* starts gametogenesis in late winter or early spring, and therefore both the size and number of eggs can be affected. Thus, the difference in timing of gametogenesis can explain the differential response of these two species to winter temperatures.

Because food supply is also important for egg production, the place in the intertidal area where bivalves live will affect egg characteristics. A field study on Balgzand confirmed that short daily immersion periods go with low condition factors, low egg numbers and small eggs. Low levels of food intake and high levels of use of body reserve material thus similarly affect reproductive output in these species.

Effect of winter temperature on the brood success of flatfish

The effect of temperature on the egg production of flatfish has been investigated in the laboratory. Adult flounder and dab were kept at 2, 6, 10°C. In spring and early summer ripe females were stripped regularly and the number of eggs estimated. At 2° the spawning period was longer, and the total amount of egg batches and number of eggs per fish were larger. This indicates that low temperatures may have a direct and positive effect on the egg production of flatfish.

Adult plaice were kept in the laboratory at 3-5°C in winter. Eggs were stripped from mature females and artificially fertilized with sperm collected from males. The fertilized eggs were incubated at 2, 6, 10°C until they hatched. After the larvae had reached the stage of first feeding they were gradually transferred to 10°C, and reared until metamorphosis was completed. Subsequent growth experiments were carried out at 15 and 20°C to find out whether incubation temperatures during embryonic development had any effect on the growth capacity of the young fish.

Incubation temperature strongly affected rate of development of eggs and larvae. Plaice larvae reared after hatching at 10°C showed slightly higher vertebral numbers when the incubation temperature of the eggs was higher. These small structural differences did not result in a clear difference in growth rate of the young plaice.

Mortality of plaice eggs developing at different temperatures was estimated with particular reference to bacterial contamination. Eggs were incubated with and without antibiotics (Penstrep) and bacteria were isolated from dying eggs. A red bacterium appeared to be particularly lethal for developing eggs.

Environmental physiology

Environmental physiology aims to study the functional interactions between organisms and their environment. Attempts are made to explain the mechanisms of the interactions in physical, chemical terms, applying simple mathematical models where appropriate.

—*Compensatory body composition changes in refuelling long-distance migrant shorebirds.* Detailed carcass analyses were carried out on Knots and Bar-tailed Godwits collected on spring staging sites in Iceland and on Texel, respectively. These analyses showed dramatic changes in their internal, physiological, state in the course of their migration and during the staging (refuelling) period. In both species there was evidence for considerable nutritional depletion during the long migratory flights towards the staging area, followed by the build up of a food processing machinery (large stomach, intestine, liver and kidney). Before the onward flight these nutritional organs atrophied to various degrees but these mass losses were more than made up by an increase in the size of the flight muscles and the heart. The latter effect could be due to an increase in power output, perhaps in combination with the need to pump blood with more red blood cells around (*i.e.* blood having higher hematocrit values, as we found in Bar-tailed Godwits).

—*Basic physiological requirements in shrimp aquaculture.* During the past decades the cultivation of shrimps (mainly Penaeid species) has increased tremendously. In the past aquaculture had been practised on a merely empirical basis. The recent success followed from intensive research.

Aquaculture requires the creation of favourable circumstances, matching the actual biological requirements of the cultivated species. During their development from egg to the (early) adult stage the requirements of the animals change drastically. This work considered some basic physiological requirements, *e.g.* those linked to the fact that living organisms continuously exchange material with their environment, necessary for their growth and maintenance and also providing a source of energy for their vital activities. During the ontogenetic development the dietary uptake and the daily excretion of metabolic end products increase. The abiotic and nutritional circumstances in an aquaculture system have to be adapted according to these changing metabolic needs. From general relations for growth, respiration and food intake, the required changes in medium dimensions (volume, surface area, depth) and in water and food supply during the development from egg to early adult stage were derived as a function of biomass.

During growth, living organisms such as shrimp absorb chemical elements from their environment in ratios as they occur in their tissues. These elements are absorbed as small molecules or as free ions, thus affecting the relative ionic composition of the medium. To avoid changes in the medium composition as much as possible, the elements in culture media should be present in the same ratios as they occur in biological material. In this work it was shown how, by using linear programming algorithms, culture media can be designed which approximate the average elemental composition of biological material.

Environmental effects of offshore mining activities

The long-term environmental effects of former discharges of oil-based mud (OBM) cuttings from North Sea offshore installations were studied further and a project on the short-term effects of a discharge of ester-based mud (EBM) cuttings was completed.

A field study was carried out around a production platform in the deposition area where the last OBM drilling had taken place 8 years before, in co-operation with IMW-TNO. Substantially elevated oil concentrations in the sediment around the platform were found up to 100 m from the platform. At 250 and 500 m concentrations were slightly above background. Residuals of discharged material could be traced by elevated Barium concentrations up to 750 m from the platform. Contamination levels in the vicinity of the platform were highest in the deepest sediment layer analysed (15-20 cm depth), supporting the conclusion that a substantial fraction of the discharged material is stored in the deeper sediment layers, where anoxic conditions may prevent biodegradation of the oil. Clear evidence for persistent biological effects was obtained up to 100 m from the platform by significantly reduced densities of a number of benthic species, including those known as most sensitive to OBM-contaminated sediment. However, compared to the situation during the first year after drilling, the extent of biological effects had decreased. At larger distances (≥250 m) effects could no longer be demonstrated and recovery of the benthos community was almost complete.

The study on the effects of discharged EBM cuttings, which started in 1993, was completed with a final field survey one year after the discharges. During this survey the presence of esters in the sediment was assessed up to 200 m from the location. Although the concentrations were significantly lower than during previous surveys, estimates of the degradation rate of the esters indicated a half-life period of several months. Persistent biological effects were also detected up to 200 m from the location. Particularly species richness of the benthos and relative fauna abundance were reduced within this zone, compared to stations at larger distances. There was a gradual decrease in the extent of effects with increasing distance from the discharge site. The species which occurred in reduced abundance in the contaminated zone were essentially the same as have earlier been found to respond most sensitively to OBM-contaminated sediment. In view of the non-substance-specific response of these species it is thought that discharges of OBM and EBM cuttings similarly disturb the oxygen supply to the sediment. Since there were clear signs of recovery of the benthic community within one year of the discharge of EBM cuttings, even at a station as close as 200 m to the location, it is expected that effects from EBM cuttings will be of considerably shorter duration than those associated with OBM cuttings.

Biometrics and statistics

As usual, in-house advice has been offered to other researchers on for instance the statistical design of experiments and field surveys, and on the statistical analysis of the data obtained. An internal course 'An introduction to probability and statistics' (nine lectures of three hours) was given for the (Ph.D.) students of the former Department of Coastal Systems.

Contributors: *J.J. Beukema* (zoobenthos), *G.C. Cadée* (algae, palaeobiology), *R. Daan* (zoobenthos, drilling muds), *R. Dekker* (zoobenthos), *M. Fonds* (flatfish), *J. Van der Meer* (biomathematician), *T. Piersma* (birds), *D.H. Spaargaren* (physiology), *H.W. Van der Veer* (flatfish), *L. Bolle* (Ph.D. flatfish), *J. Van Gils* (birds), *P.J. de Goeij* (Ph.D. *Macoma*), *P.J.C. Honkoop* (Ph.D. bivalves), *P.A. Walker* (Ph.D. rays), *W. de Bruin* (benthos), *J. Hegeman* (algae), *D. Kwast* (bivalves), *M. Mulder* (zoobenthos, drilling muds), *P. Van der Puyl* (fish), J.IJ. Witte (fish), *J. Zuidewind* (benthos).

2. STRUCTURE AND DYNAMICS OF BENTHIC ECOSYSTEMS

Small food web studies (Protozoans)

These studies concern trophic relations between heterotrophic nanoflagellates and bacteria in marine sediments and the microbial characteristics of reef water columns. Variation of nanoflagellate densities, community feeding activity and grazing rates on bacteria, *e.g.* along depths gradients in the eastern Mediterranean (CINCS), were determined. A technique used to measure grazing of nanoflagellate on bacteria-sized particles involves the use of FLB (fluorescently la-

belled bacteria) as prey particles. To avoid the limitations of the FLB technique, such as low consumer numbers in sediments and in reef waters, the potential of cyanobacteria feeding as a standard technique is investigated.

Studies on microbial processes in reef water columns relate to studies on the reef bottom community dynamics. They focus on microbial variables in the water column in relation with coral reef eutrophication and the linkage to reef benthos. The bacteria/flagellate filtration capacity of a series of reef bottoms is under investigation. The role of nanoflagellates in the water column as bacterivores is studied in grazing experiments on pristine and polluted reefs. Elevated levels of nutrients and increased bacterial production were observed as a result of sewage pollution. The algal population in eutrophicated waters is dominated by large species of diatoms and dinoflagellates, while oceanic and coastal waters contain mainly smaller cells such as cyanobacteria.

The impact of the coral reef benthos on microbial parameters is being studied. Higher levels of nutrients and specific bacterial growth rates were observed in well-developed reefs, but abundances of bacteria and flagellates were lower. In contrast to oceanic bacteria, those in waters above coral reefs were able to grow immediately upon the addition of carbon sources. This means that bacteria in oligotrophic systems are in a minimum maintenance state and that the coral reef must excrete sufficient carbon and nutrients to support the enzymatic systems needed for resource uptake and cell division.

Dynamics and diversity of coral reefs

Studies of key processes in reef community composition and diversity focus on short- and long-term dynamics in coral populations including the role of life history strategies in modular/clonal organisms. To understand organismal adaptation and the influence of sedimentation on coral health we determined regeneration rates of superficial lesions (standard-sized wounds artificially made in the surface of coral colonies) as a parameter of coral health. We measured regeneration efficiency of surface tissue lesions in two coral species along a sedimentation stress gradient using a descriptive and experimental approach. The descriptive study yielded data on regeneration rates at three sites. In the experimental study we subjected coral lesions to different sedimentation regimes. The data will be analysed for variation due to location along the gradient, species, water depth, coral tissue depth and effect of sedimentation.

An important aspect of the relation between a reef bottom community and its environment is the link between water column characteristics and community species competition. Microbial processes in the water column (see small food web studies) are related to the filter feeding properties of the benthos. The postulated correlation between densities of filter feeders and eutrophication was investigated in terms of differences in densities of boring sponges. These animals are dominant bio-eroding reef bottom organisms and their occurrence was studied on pristine and polluted reefs. Studies on long-term change (since 1973) in reef bottoms are continued.

The North Sea as a sink for carbon

In February, May and August 1994, four stations in the North Sea were visited to sample near-bottom particulate organic matter (POM). The POM was collected through sediment trap, sediment recorder and near-bottom water pumping. The samples were analysed on carbon, nitrogen, phytopigments and fatty acid methyl esters.

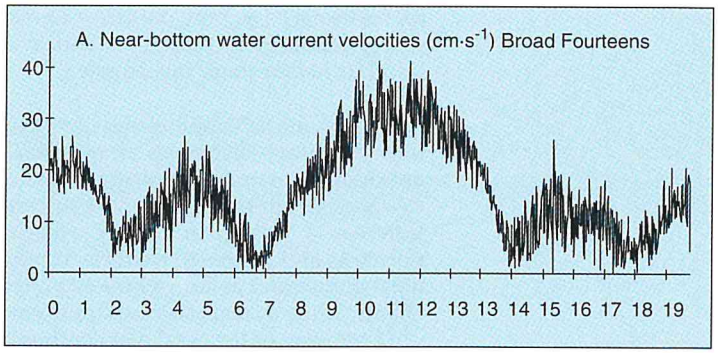
This study supports earlier findings relating higher growth rates of macrobenthos to a higher quality of near-bottom particulate organic matter. This study underlines the importance of the local hydrography for the quality of near-bottom POM, the food source of benthic organisms.

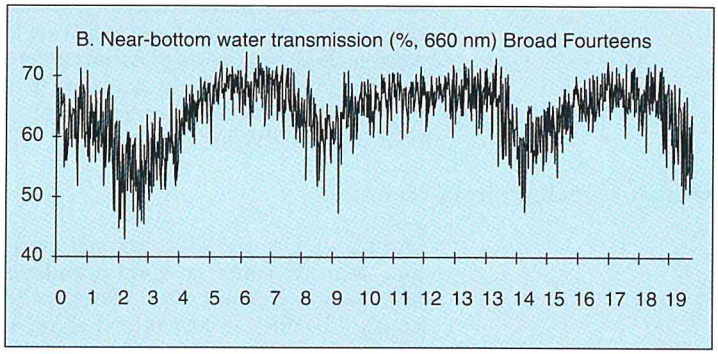
BIOMON (BIOMONitoring North Sea)

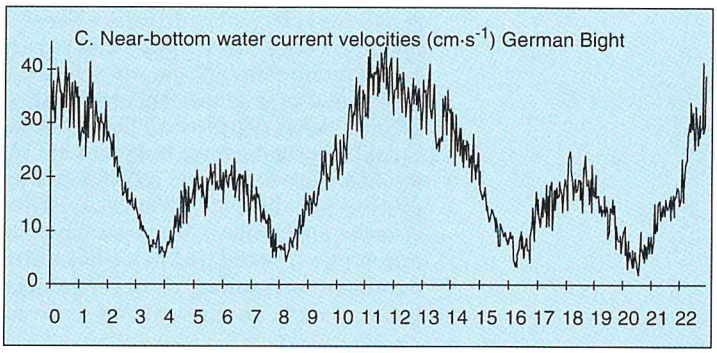
This project aims to obtain insight into the year-to-year variations of the macrobenthic communities in the Dutch sector of the North Sea and to detect trend-like changes possibly indicating anthropogenic influences on the marine environment. It is an initiative of the National Institute for Coastal and Marine Management (RIKZ) of the Ministry of Transport (Rijkswaterstaat). In spring 1994 boxcore samples were taken from 25 stations distributed over four transects perpendicular and one transect parallel to the Dutch coast. This survey was the fourth since 1991.

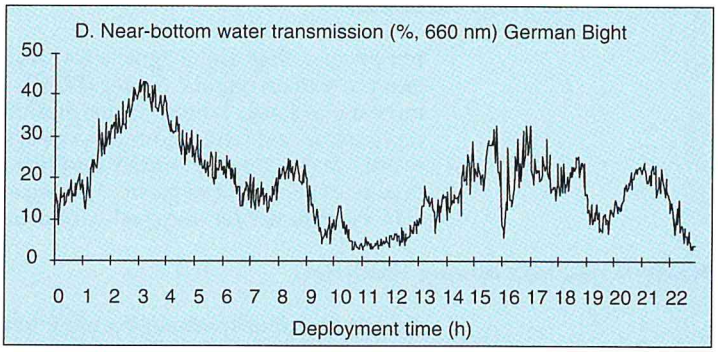
The data of the period 1991-1994 show more increasing than decreasing trends in time. Furthermore, the density and the number of species of the macrobenthic taxa were more variable than the biomass. Most trends along the transects observed in 1993 were not found in 1994, or changed in the opposite direction.

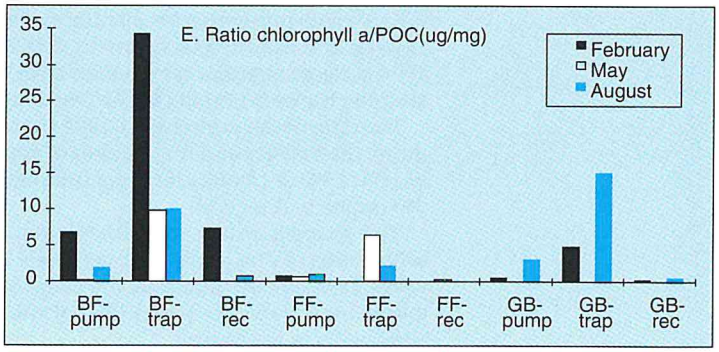
The changes of the macrobenthos had a local character and were often not observed in the whole area of one cluster. We conclude that the present data spanning four years of investigation (1991-1994) merely illustrate the year-to-year fluctuations of the macrobenthic fauna on the Dutch continental shelf. To get an idea of the effects of the human activities, information from longer time series is necessary.











The differences in quality of the near-bottom organic particles collected by near-bottom pumping, sediment trap and sediment recorder, between the different sample locations were well explained by the differences in local hydrography. Station Broad Fourteens (BF) was characterized by relatively strong near-bottom currents and no net deposition of organic and fine mineral particles. Hence, although turbulence was high, resuspension of sedimentary material was relatively low (A, B). While the concentrations and amounts of carbon trapped on this location were low, this carbon was rich in phytopigments (E) and polyunsaturated fatty acids, both indicating high quality organic material. At stations Frisian Front (FF) and German Bight (GB), where deposition of fine silty particles and organic particles occurs, the tidal bottom currents were responsible for resuspension of sedimentary material (C, D). This resulted in relatively high carbon loads in the lower water layers, which were lower in phytopigments (E) and fatty acids, and appeared more degraded than at station Broad Fourteens.

Pelagic-benthic coupling in the Sea of Crete (CINCS)

In February and September 1995, two successful cruises were carried out in the Mediterranean in the framework of the MAST programme CINCS, which studies pelagic and benthic processes and their interaction in the Cretan Basin. This sea is poorly studied and may be one of the most oligotrophic areas in the world. The benthic activity and standing stock in this sea were expected not only to reflect this oligotrophy but also to display little or no seasonality.

These assumptions were tested in a series of five cruises over a two-year period. The primary task of the NIOZ participants in CINCS was to measure *in situ* sediment oxygen consumption (SCOC) with the BOLAS-lander in winter (February, with relatively high production) and summer (September, with low production). Other sediment variables measured were the abundance of heterotrophic flagellates and bacteria in the sediment (co-operation G. Nieuwland, R.P.M. Bak), phytopigment content and DNA activity. The cruises were carried out with the RV 'Aegeao' of the National Centre for Marine Research (Athens) and in close collaboration with the Institute for Marine Biology Crete.

RV 'Aegeao' of the National Centre for Marine Research, Athens.
Photo: G. Nieuwland.

Fourteen successful lander deployments reveal a distinct seasonal signal in both SCOC and flagellate abundance. The two years investigated both had lower values in September than in February. These results contrast with our initial expectation of a lack of seasonality. An exception is the shallowest station where summer values are higher, indicating an uncoupling between this stations and the others. Actual bi-monthly measurements show that primary production does not vary consistently over the year. This leaves the cause of the pronounced seasonality of the benthic activity unexplained. More insight into variations in benthic food supply will be derived from current qualitative and quantitative analyses of the sediment and of the contents of the sediment traps on the BOLAS lander and on the long-term moorings.

Benthic boundary processes at continental shelves and deep-sea slopes

OMEX 1995 (Ocean Margin Exchange: an EC-MAST funded programme) addresses the question of shelf-edge exchange of particles. NIOZ participated in the group 'Benthic Processes', and studied carbon deposition across the continental slope. Topics were the seasonal and interannual variations in organic matter supply, the quality of food particles for the benthic community and sediment oxygen consumption in the region south of Ireland. Results from the 1993 and 1994 cruises at the OMEX transect across the Goban Spur point to a decrease in benthic activity, standing stock and fresh organic matter availability with increasing water depth rather than indicating an enrichment which could be attributed to particle transfer across the slope. We found pronounced seasonal patterns in organic matter deposition, in sediment chlorophyll *a* content and also in silica effluxes, but significantly enriched zones could not be traced.

Any downslope transport that may exist is, therefore, not likely to occur over the full extent of the continental margins. Forced by the geomorphological structure and local bottom currents, particles are thought to be guided along specific pathways. The complicated structure of the heavily eroded escarpments southwest of Ireland supports this idea. In short: downward transport occurs through the submarine canyon systems rather than over the sloping ridges and plains (such as the Goban Spur). Consequently, accumulation of deposits is likely to be found in the 'delta areas' in front of the canyons and in sheltered spots behind elevated bottom structures, ridges and mounds.

Important clues as to the existence of deposition areas were expected from the presence and distribution patterns of long-lived large organisms, whose existence must be related to sufficient

food supply over long periods (years). Such a search, however, would entail the difficult and time-consuming technique of deep-sea trawling and the use of camera surveys. Fortunately, this year an opportunity was presented during the first leg of the August/September cruise with RV 'Pelagia' in the Celtic Sea. At the Goban Spur an Agassiz deep-sea trawl was successfully deployed over the full depth range from 200 to 4500 m. Trawling was also completed at three stations at a northern transect ranging from 1200 m to 3600 m in the Porcupine Bight. Finally, complementary bottom sections were cored at four abyssal stations at the foot of the continental rise: two in front of major canyon systems and two others at contrasting areas in between.

Although a major part of the collection is still being processed, the first results show a great diversity in numbers, species composition, size distribution and feeding modes, pointing to differences in organic matter supply and its availability —suspended or deposited— to organisms. Unexpected was the occurrence of numerous giant life forms: rabbit-sized sea-cucumbers, anemones *etc.*

New was also the discovery of a mucus layer at the ocean bed consisting of patches, blobs and berries of some transparent, greenish jelly, up to >5 mm thick. This substance looked completely different from any normal appearance of so-called 'fluff'. It was found at all abyssal stations below 3000 m. Samples of the jelly are now being analysed. The first results point to an easily degradable carbon source, rich in diatom frustules, bacteria, fresh phytopigments and RNA. Is this perhaps a rediscovery of the legendary *Bathybius haeckelii*, the primitive form of life that has been preserved in the deep ocean and from which all higher organisms have descended? (Challenger Narrative 18, 1885, tome 1, second part, p. 939.)

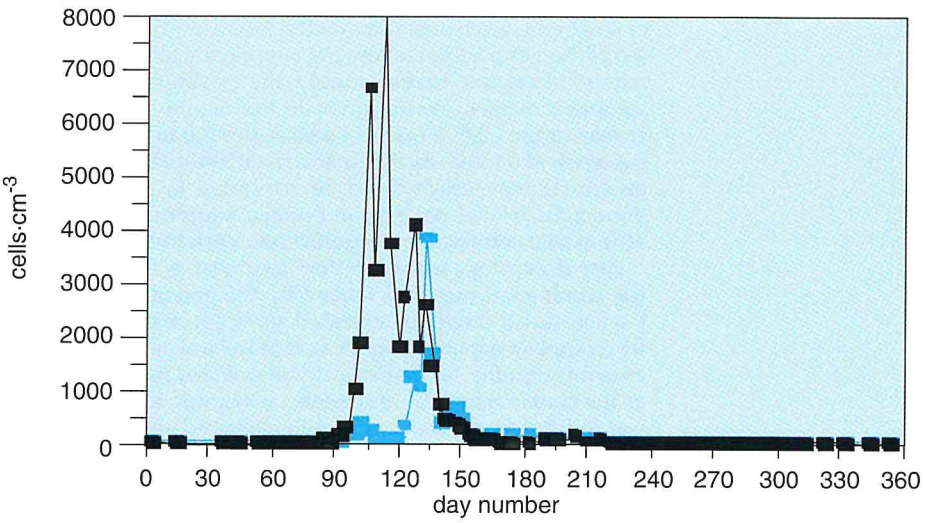
Contributors: *R.P.M. Bak* (corals, protozoans), *G. Duineveld* (macrozoobenthos), *F.C. Van Duyl* (microorganisms), *P.J.A.W. de Wilde* (benthos, carbon), *A. Boon* (Ph.D. SOD, fatty acids), *G.J. Gast* (Ph.D. corals, microorganisms), *B.J.M. Hondeveld* (Ph.D. flagellates), *S. Holtmann* (zoobenthos), *J. Belgers* (zoobenthos), *M. Lavaleye* (megabenthos), *T. Tahey* (macrofauna, benthos metabolisme, *R. Witbaard* (ecology *Arctica*), *E. Berghuis* (oxygen, phytopigments), *B. Kracht* (zoobenthos), *A. Kok* (oxygen, RNA/DNA), *W.E. Lewis* (microbiology), *G. Nieuwland* (protozoans), *J. Van der Weele* (pigment analyses).

3. LONG-TERM STUDIES OF MARINE ECOSYSTEMS

Long-term studies on dynamics of populations

—*Phytoplankton*. The development of phytoplankton in the Marsdiep tidal inlet has now been followed for more than 20 years, and no two years are exactly the same. 1995 proved to be another a good *Phaeocystis* year, albeit with only one broad spring peak lasting from early April to early June, and later in summer only rarely more than 1000·cm^{-3}. The spring diatom peak usually preceding this *Phaeocystis* peak was not very well developed: peak cell numbers of 3300 cells·cm^{-3} were found on 13 April, *Phaeocystis* peaked with 90 000 cells·cm^{-3} on 24 April. At the end of their bloom, *Phaeocystis* colonies were invaded by a small pennate diatom (*Pseudonitzschia delicatissima*; det. G. Hassle, Oslo); this as such was not new, but never were their numbers as high as this year. They caused a second diatom peak on 15 May of over 38 000 cells·cm^{-3}, higher than ever observed before. Low biomass of phytoplankton after the *Phaeocystis* peak may well be due to the extremely dry summer resulting in low input of riverine nutrients.

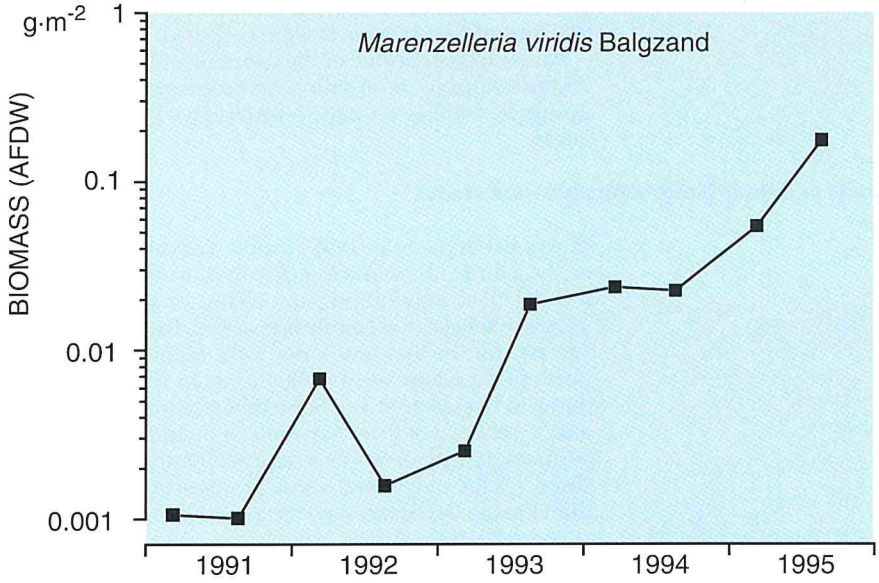
Much progress was made in the study of trends in the Marsdiep phytoplankton data. All cell counts have been converted to a computer-stored data base.



Seasonal curve of diatoms (blue squares) and *Phaeocystis* (black squares) cells in the Marsdiep, 1995. The diatom peak in May was due to a small pennate living in *Phaeocystis* colonies.

—*Macrozoobenthos.* The long-term series of macrozoobenthos data collected twice annually at 15 stations on Balgzand, which started in 1970, was continued and showed all-time high values for total biomass. Reductions in phosphate concentrations have therefore not led to lower levels of zoobenthos biomass. The macrobenthos sampling programme in the eastern part of the Dutch Wadden Sea, at the request of Rijkswaterstaat (RIKZ), did not show similarly high biomass values. In all areas recruitment success of bivalves was lower than on average, due to the relatively high temperatures during the previous winter.

The spionid polychaete *Marenzelleria viridis*, originally from the western Atlantic, appeared in the Netherlands in 1983, and is an inhabitant of the Balgzand tidal flats since 1991. Densities, biomass and distribution over Balgzand has rapidly increased since then.



The originally western Atlantic spionid polychaete *Marenzelleria viridis* was first discovered in the Wadden Sea in 1983. Since 1991 this immigrant is an inhabitant of the Balgzand tidal flats. Its biomass, as well as densities and distribution over Balgzand increased rapidly since then.

This year, special attention was paid to the effects of winter temperature on the dynamics of tidal-flat zoobenthos. Cold winters cause higher-than-average mortality in sensitive species. More than one third of the macrozoobenthic species on Balgzand showed such enhanced mortality in severe winters. Examples of well-known species include the bivalves *Cerastoderma edule, Angulus tenuis* and *Abra tenuis* and the worms *Lanice conchilega* and *Nephtys hombergii.* Some epibenthic species, including the shore crab *Carcinus maenas* and the brown shrimp *Crangon crangon* appear later in spring and in lower numbers on the tidal flats after cold than after mild winters (see also theme 2).

As winter temperatures are approximately similar over the entire Wadden Sea, fluctuations in the size of populations in many species may be expected to be synchronized over vast areas. Several examples of such parallel fluctuations in various distant parts of the Wadden Sea became available by co-operation with research groups monitoring the zoobenthos on tidal flats at more easterly locations in the Wadden Sea, *viz.* off Groningen by RIKZ (Dr. K. Essink) and off Norderney by the Niedersächsisches Landesamt für Ökologie, Forschungsstelle Küste (Dr. H. Michaelis).

—*Fish.* Detailed analysis of long-term data series of abundance and distribution of *Raja* species in the North Sea has shown that local depletions of stocks occurred in the southern North Sea shortly after the second World War and during the early 1960s. This was especially marked in Dutch coastal waters for the thornback ray (*Raja clavata)* and the common skate (*Raja batis*), which have been rare since the late 1950s. The intensive demersal fishery is probably responsible for the decline of stocks and also prevents recolonization of the affected areas. In the central North Sea, the starry ray (*Raja radiata*) has increased in abundance over the last 20 years, despite intensive fisheries. Studies continue in order to unravel the life-history and reproductive strategies of the rays and skates occurring in the North Sea in order to understand such shifts.

—*Birds.* The long-term ringing-activities and the studies on the breeding population and reproductive success of eiders *Somateria mollissima* were continued in 1995.

The Vlieland colony was visited during the last week of April and the first week of May. In comparison with the breeding season of 1994 in the Kroon's Polder, the Zuid Bomenland and on the Posthuiskwelder the numbers of nests showed a dramatic decrease of more than 60% in 1995. Also, the number of clutches taken by predators increased up to 14% (6.5% in 1994), and clutch-size of remaining nests was lower than usual. Though it is hard to prove, there are strong indications that the reduction is due to predation by rats. In the early 1990s the brown rat *Rattus norvegicus*

obtained a foothold on Vlieland, and has now spread throughout the island.

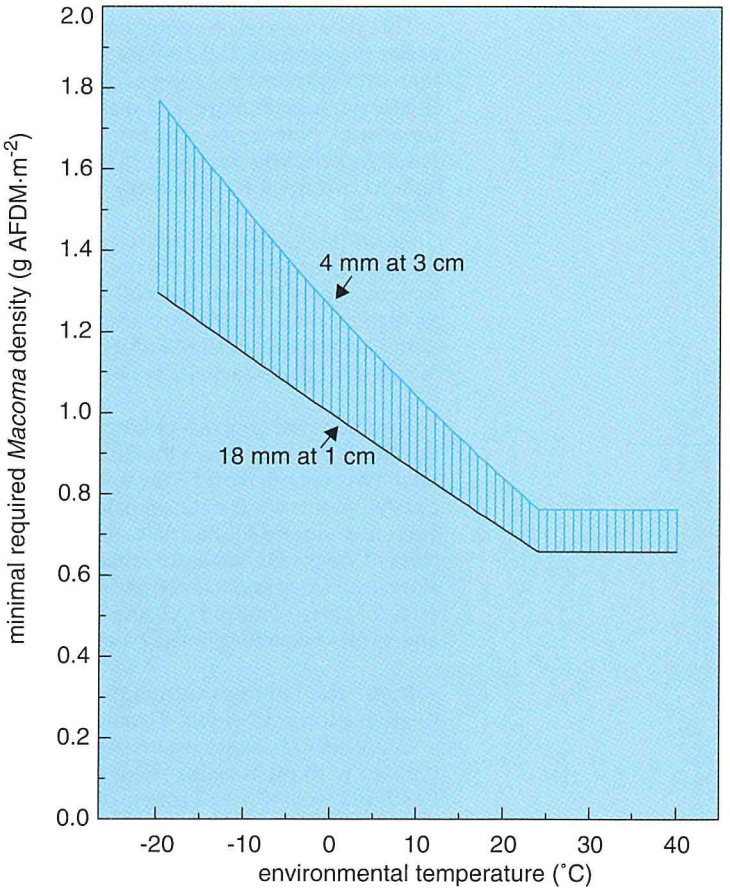
From high-tide counts in the first week of May a total number of 2247 breeding pairs has been calculated. In contrast to the reduction of the number of nests, the reproductive success was good. In co-operation with employees of State Forestry, 747 fledglings were counted in the first week of July.

NIOZ participated in the Bewick's Swan Expedition 1995 by Prof. R. Drent and co-workers of Zoological Laboratory (University of Groningen), researchers of the Limnological Institute, Nieuwersluis, and Danish National Environmental Insitute in Rønde to the islands of Mus'yugskyi and Kustavoy in the Dvina Delta and the White Sea (Russia) in May and June. Censuses were carried out of the bewick's swan *Cygnus columbianus bewickii* and the brent goose *Branta bernicla* on their spring-migration towards the Arctic breeding-grounds. The feeding dynamics of both species were studied; in co-operation with local hunters, measurements and body masses from several tens of *Branta bernicla* were collected.

An ecological profile of the common eider *Somateria mollissima* has been prepared summarizing all the available information on breeding distribution and numbers, wintering distribution and numbers, feeding ecology, reproductive parameters, threats and trends of eiders in The Netherlands.

Knots and their benthic bivalve food stocks

In August-September 1995 a study was carried out on the numerical abundance of Knots and other shorebirds, their feeding distribution and diet and benthic bivalve-food availability on the intertidal flats surrounding the island of Griend in the western Wadden Sea. This was the 8th successive year of a continuing series. Knots were fairly abundant, and fed in large numbers on *Macoma* for the first time since 1988. *Macoma* was found on the flats east of the island, rather than north of the island as in 1988. Just as in 1988 and 1989, there was a diet shift from *Macoma* to *Hydrobia* in late August and September, correlated with an increase in the depth of living of *Macoma*, and a decrease of their harvestable biomass. It was possible to estimate the minimal harvestable biomass density of *Macoma* required on the basis of (1) the empirical energy requirement relationships, (2) the nutritional value of *Macoma*, and (3) the digestive efficiency of Knots and the functional response curves for Knots feeding on *Macoma*.



Graph of the minimal harvestable biomass density of *Macoma balthica* (only medium-sized bivalves living in the upper 3.5 cm of the sediment) as a function of the environmental temperature experienced by Knots. This function is a composite of the functional response of Knots feeding on *Macoma* and the 'Scholander' curve summarizing heat loss *vs.* environmental temperature. Below 24˚C a Knot has to produce extra heat to maintain a body temperature of 41˚C, above 24˚C no extra heat is required. These are the so-called maintenance costs. The additional flight and foraging costs are included in this model. For Knots to achieve a certain intake rate, feeding on deeply buried small *Macoma* requires a higher minimal biomass density than feeding on big shallowly buried *Macoma*. The shaded area covers the relationships for all size classes and burying depths. We assumed a daily foraging time of 12 hours.

Parallel changes in fish recruits and their environment in the western Wadden Sea

The Wadden Sea is an important nursery of the North Sea. The NIOZ long-term series of fyke catches in the Marsdiep (the westernmost inlet of the Wadden Sea) was used to examine year-to-year variation in the abundance of fish recruits. The density of most species was relatively low in the early 1970s and relatively high in the mid-1980s. Variation in 0-group fish abundance was found to correlate with the strength of the North Atlantic Oscillation index (an index of the westerly circulation over the North Atlantic) and water temperature. Recruit numbers of the northern species herring, cod, whiting, lumpsucker and plaice were high in years with cold winters, while recruits of the southern twaite shad were more common during mild winters. Recruitment of the latter species may, however, be favoured by the low run-off of the rivers in years with hot and dry summers. The correlation between fish recruit abundance and the NAO index suggests additional influence of large-scale environmental factors such as hydrographic conditions in the North Sea.

Multivariate Analysis

Multidimensional scaling methods such as Principal Component Analysis (CA) and Canonical Correspondence Analysis (CCA) are becoming increasingly popular in biology. These techniques can be used to analyse relationships between or within multivariate biological data and environmental variables. However, these methods ignore the time order of the data. In this research, multivariate techniques are modified and extended to cope with the time order.

In a first attempt, scaling methods are applied to approximately 40 macrozoobenthic species measured at 15 sites on the Balgzand in year t (t=1970-1995). The results of these scaling techniques are compared for the 26 years. Preliminary results indicate that internal relationships between (1) species and (2) sites changed in the years 1979 and 1993.

In co-operation with the Department of Mathematical Sciences, University of Aberdeen, this procedure will be improved and extended .

Effects of trawl fisheries on the ecosystem of the North Sea

Comparative field studies (EC-project IMPACT-II) were carried out on the direct mortality of bottom fauna due to trawling with different types of commercial trawls. In a coarse-sand area, effects were studied of 12-m beamtrawls, 4-m normal beamtrawls, and of 4-m beamtrawls rigged with chains mats. In a fine-sand and soft-bottom area, effects of 12- and 4-m beamtrawls were compared with effects of ottertrawls. Macrofauna was sampled both before and after experimental trawling. Abundant (*e.g. Angulus fabulus*) or vulnerable macrofaunal species (*Echinocardium cordatum*) were sampled with a Reineck-boxcorer or a Van Veen grab. Less abundant macrofauna was sampled with the Triple-D, which collects a 10-cm-deep strip of the bottom sediment during a haul of several hundred metres (mesh size 0.7x0.7 cm). During the 1995 field studies, the prototype Triple-D was adapted to improve both the penetration into a hard-sand seabed and the washing out of sediment during longer hauls. Total weight of the dredge was enlarged by 25% and the cross-section of cage and net was made twice as large. Both a test on catch efficiency and video recordings showed that the transport of sediment had been improved considerably due to these changes. Further testing of the improved prototype as well as the development of a closing mechanism will be continued.

After duplicate trawling of a number of well-defined lines, remaining densities of benthic fauna were subtracted from densities before trawling. The decreases in density were corrected for the numbers of animals that survive being caught in the trawl and thrown back into the sea. In all trawl studies *Echinocardium* living in the upper 10 cm showed high mortality (70-90% of initial density). As mortality of specimens living deeper in the sediment is low, population mortality will be much less. Molluscs (*e.g. Angulus, Phaxas, Spisula, Chamelea, Dosinia, Gari)* showed mortalities between 10 and 80%, and the mobile species *Asterias* and *Liocarcinus* showed 'negative values', indicating that these scavengers immigrated into the trawled area within 24 hours of trawling. All studies indicated that the direct mortality of invertebrates was due to damage and disturbance of the fauna by the passage of the trawl rather than to actual capture of the organisms.

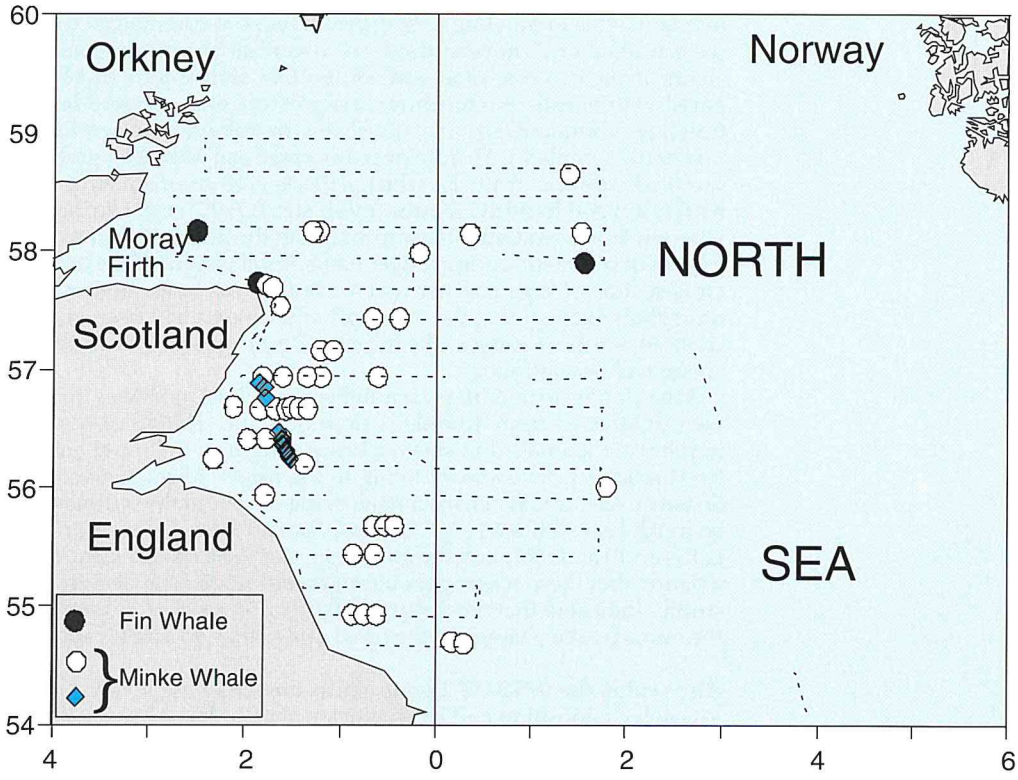
Also within the IMPACT-2 programme the following investigations have been carried out:
—Catch composition and catch efficiency of 4- and 12-m beamtrawls for sole fishing. Comparative hauls were made with RV 'Tridens' and catch compositions were analysed with particular reference to commercial fish, discard fish and benthos.
—The activity of opportunistic 'scavenging' species immigrating into a recently trawled area and feeding on fishery discards. Repeated trawling with 12-m beamtrawls over the same line resulted in exponentially decreasing numbers in the catches of most fish and benthos. Dab, whiting, gurnards and dragonets often did not show a decrease in numbers in the catches, indicating that these species rapidly immigrated into the trawled area. Sampling on a heavily trawled area, with a fine-meshed 3-m beamtrawl, yielded evidence of immigration of many fish species (dab, dragon-

et, plaice) and invertebrates (starfish, swimming crabs). Investigation of stomach contents showed that the immigrating fish fed on exposed and damaged benthos, particularly on mollusc meat and damaged crustaceans.

—A large number of traps were set out on the North Sea bottom, baited with fishery discards such as dead fish, crushed crabs, crushed molluscs or cr ushed starfish. The traps were left on the bottom for two days attached to a chain and marked by buoys. Dead fish as bait generally attracted starfish and swimming crabs, whereas hermit crabs were more attracted by mollusc meat.

Seabirds, cetaceans and fisheries interactions

—*Seabirds and discards.* In 1995, the EC-funded programme on the consumption of discards by seabirds in the North Sea came to a successful end with the publication of the final report (NIOZ Report 1995-5). In this project, co-ordinated by NIOZ, institutes and organizations from five countries around the North Sea co-operated. The project provided information on the numbers and spatial distribution of scavenging seabirds, on co-occurrence of seabirds and commercial trawlers, on dominance hierarchies among scavengers in areas differing in species composition and relative abundance of seabirds, and provided quantifications of proportions of discarded biota consumed by seabirds. Current knowledge on quantities of fish discarded from commercial fisheries in the North Sea was summarized and consumption rates of seabirds throughout the North Sea were used to estimate total consumption by scavenging seabirds. From discard experiments, it was estimated that overall consumption rates varied between 95% for offal, 80% for roundfish, 21% for flatfish, and 6% for benthic invertebrates. Consumption rates and total numbers of scavengers were relatively high in the northwestern part of the North Sea, and scavenging appeared to be of greater significance in winter than in summer. The densest concentrations of seabirds located were birds feeding 'naturally' on prey near the surface. On fishing grounds, however, thousands of scavengers could assemble round a single trawler. Yet, the distribution of none of the species could be explained in terms of trawler densities, but the amount of discards produced is immense and seabirds utilize discards and offal on a great scale, indicating that measures to reduce discards in commercial fisheries are likely to affect feeding opportunities for scavenging seabirds.

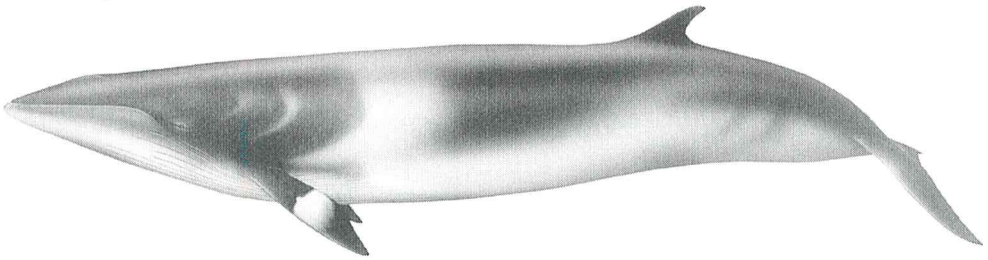


Study area, showing ship-track during observations (dotted line), observations of (probably) Fin Whales and Minke Whales. Sightings of Minke Whales observed while 'off effort' (steaming towards Aberdeen) are shown as diamonds.

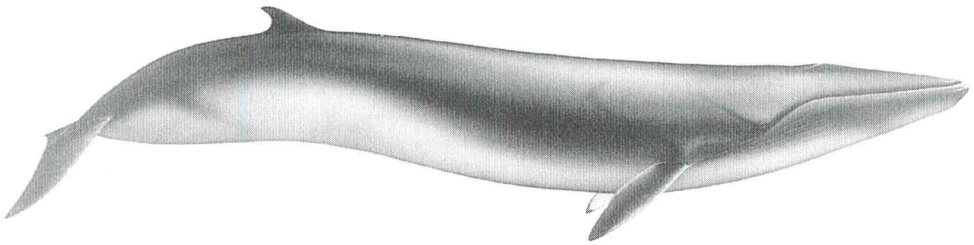
—*Seabirds, cetaceans and fish stocks.* A pilot study was performed in association with the acoustic survey for herring in the northwestern part of the North Sea in July 1995. This survey, organized by the Netherlands Institute for Fisheries Investigations (DLO-RIVO), examined the possibilities of linking the acoustic information on fish (potential prey) densities with the observed densities of top predators. The cruise provided a wealth of data which will be analysed and published in

early 1996. Large numbers of seabirds and cetaceans, including the unexpected Fin Whale *Balaenoptera physalus*, were found feeding in coastal areas rich in sandeel balls near the surface. The feeding range of Bass Rock Gannets *Sula bassana* was 'mapped' and explained in terms of fish and dolphin abundance. Offshore staging areas of Arctic Terns *Sterna paradisaea*, which were probably of significance for failed breeders from Orkney and Shetland, were discovered and described. The dispersal of juvenile auks (Guillemot *Uria aalge*, Razorbill *Alca torda*, and Puffin *Fratercula arctica*) and feeding aggregations of adults without chicks of these species will be described and explained in terms of fish abundance, distance to the coast and hydrographical features.

Balaenoptera acutorostrata



Balaenoptera physalus



Contributors: *M.J.N. Bergman* (zoobenthos, fisheries), *J.J. Beukema* (zoobenthos), *G.C. Cadée* (algae), *R. Dekker* (zoobenthos), *M. Fonds* (fish), *H.J. Lindeboom* (ecologist), *K. Philippart* (data analysis), *H.W. Van der Veer* (fish), *A. Zuur* (mathematician), *S. Groenewold* (Ph.D. fish), J. Van Santbrink (zoobenthos, fisheries), *C.J. Camphuysen* (birds), *P. Duiven* (birds), *J. Hegeman* (algae), *C.J.N. Winter* (birds).

LAND-OCEAN INTERACTIONS IN THE COASTAL ZONE (LOICZ) CORE PROJECT OFFICE

LOICZ is one of seven Core Projects of the International Geosphere-Biosphere Programme: A study of Global Change. As its name implies LOICZ is that component of the IGBP which focuses on the area of the Earth's surface where land, ocean and atmosphere meet and interact. The overall goal of the project is: to determine at regional and global scales, the nature of that dynamic interaction; how changes in the various compartments of the Earth system are affecting coastal areas and altering their role in global cycles; to assess how future changes in these areas will affect their use by people; and to provide a sound scientific basis for future integrated management of coastal areas on a sustainable basis.

The coastal domain is of global importance for both humanity and for geochemical cycles, despite its comparatively small surface area and volume. Since the world's coastal areas are home to a high proportion of the total global population, and contain many important economic resources, changes in coastal environments result in social and economic change which in turn feedback to the natural environment. Understanding this feedback is therefore of fundamental importance to understanding the process of global change.

Staffing of the Office at NIOZ

The project commenced in 1993 with the publication by the IGBP of the LOICZ Science Plan and in December 1993 the LOICZ Core Project Office was officially opened at the Netherlands Institute for Sea Research. The office is financially supported by the Netherlands Government and is scheduled to run for 10 years. The staff consists of Dr John Pernetta (Project Director), Ms Sheila May Lunter (Office Administrator), Mr Paul Boudreau (Project Scientist coastal databases and modelling management) and Ms Mildred Jourdan (part-time Administrative Assistant).

Publication of the Implementation Plan and Second LOICZ Open Science Meeting

The development of the Implementation Plan, which details the manner in which the scientific issues and uncertainties surrounding the role of the coastal domain in the functioning of the Earth system need to be addressed, involved a network of over 1,000 coastal scientists from 124 countries. The final draft of this document was approved by the SC-IGBP in December 1994 and published in March 1995 (IGBP Report No. 33). In late April 1995, the Second LOICZ Open Science Meeting was convened at the Marine Science Institute of the University of the Philippines. Attended by 203 natural and social scientists from 45 countries this provided a forum in which to explore the mechanics of how to implement the project. Both regional and topic oriented discussions were convened, resulting in the identification of potential core research nodes and initiation of specialised networks upon which the future success of LOICZ will depend. The meeting was supported by a number of international agencies with interests in coastal science including the Intergovernmental Oceanographic Commission of UNESCO, IUCN-The World Conservation Union, and the Commission of the European Union with whom the LOICZ Project maintains strong collaborative links.

Activities of the Core Project Office

To deal with the methodological problems associated with developing global perspectives of the role of the coastal sub-system in the functioning of the Earth system, a coastal typology is being developed, which will be used as a framework for preparing regional and global syntheses and to identify coastal areas and types for which more empirical data are required. The Food and Agriculture Organisation of the United Nations and the Netherlands Geological Survey are collaborating with LOICZ on this issue.

Recognising that considerable bodies of empirical, *in situ* data already exist in the literature for a number of areas of interest to LOICZ the project has initiated, in collaboration with the World Health Organisation and the Global Environment Monitoring System (GEMS) of the United Nations Environment Programme (UNEP) the compilation of data relating to riverine discharge to the coastal zone. A draft document 'River discharge to the Sea: A global river Index' was published and circulated by LOICZ in April 1995 and further amplification and expansion of this database will be undertaken over the next biennium. Planning has been initiated in 1995 for the compilation of a comparable database of groundwater discharges in collaboration with the Russian Academy of Sciences.

At the Fourth Scientific Steering Committee meeting held in the Philippines a programme of activities in four countries of the Southeast Asian Region was approved as Core Research. Executed by coastal zone researchers on the staff of four institutions in the region this is a collaborative pro-

gramme funded by the Netherlands Foundation for the Advancement of Tropical Research (WOTRO) through the Southeast Asian Regional Committee for START (SARCS) and co-ordinated by the LOICZ Core Project Office on behalf of the LOICZ-SSC.

To provide a framework for future national and regional research, and to ensure that data generated through such research are comparable and compatible, two sets of guidelines are currently under development through LOICZ. Another component of this framework, the LOICZ data system plan is under active development in collaboration with the IGBP-DIS. When completed this will document the expectations of the LOICZ project and its component researchers in terms of data compilation, management, access and exchange.

The LOICZ Research Agenda

The physical and biological heterogeneity of the world's coastlines, combined with the variety of social cultural and economic conditions driving change in these areas result in a complex interplay of processes such that conditions and the resultant dynamic equilibrium in any one area of the world's coast can be considered unique. Developing models, scenarios and syntheses which allow a wider spatial or temporal view of these dynamic systems is a significant scientific challenge. Considerable effort has been expended in 1995 in networking and the development or regional approaches to LOICZ research covering areas such as Southeast Asia, East and West Africa and topic fields such as linkages between natural science research and economics. To achieve its overall global goals and objectives LOICZ will need to actively involve the scientific communities at national level and during 1995 the Core Project Office Staff have supported several national and regional initiatives concerned with the development of LOICZ research projects and activities.

In order to develop regional and global syntheses of any single flux from land to ocean (sediments, freshwater, or nutrients for example) this diversity of natural and human conditions must be filtered in such a way that the dominant factors controlling present fluxes can be identified, and quantified. The effects of global change on these factors, whether positive or negative, must then be determined if future conditions are to be adequately described via scenarios, or built into more dynamic models for producing forecasts. In the short term, regional and global syntheses of existing empirical data can be produced which provide a basis for expansion of the temporal and spatial scale of various types of coastal models. Catchment basin models which adequately describe the driving forces controlling discharge from catchments of different types to the coastal ocean can be constructed allowing extrapolation from catchments of known to unknown characteristics. Coastal ocean carbon budgets and flow models once fully validated, can be used in conjunction with the coastal typology to provide better estimates of the role of the coastal ocean in the global carbon cycle. These directions have been pursued in various ways by both the CPO and the members of the Scientific Steering Committee in 1995.

As noted in the LOICZ Implementation Plan, LOICZ is a project which addresses the effects of cumulative changes to the world's coastal zones, the effect of these changes on the functioning of the earth system as a whole, and on the human populations of coastal areas. The complexity of the project in terms of the scientific issues and uncertainties which need to be addressed in achieving the LOICZ goals will necessitate continued strong co-ordination by the Core Project Office in 1996 if the short-term objectives of the project are to be met.

Contributors: *J.C. Pernetta* (project manager), *S.M. Lunter* (office administrator), *P.R. Boudreau* (project scientist), M.T. *Jourdan* (assistant secretary).

THE NETHERLANDS MARINE RESEARCH FACILITIES (MRF)

MRF advises GOA on the technical and financial aspects of the execution of the National Programme for sea research, and it provides suitable ship capacity and sea-going equipment. When sea-going projects have been approved and granted by GOA, MRF takes care of the planning, preparation and execution of the cruises. MRF also advises GB-BOA on long-term investments. The advice is prepared by the programme co-ordinator in consultation with the financial and technical division of NIOZ, scientists and the user advisory committees (on CTD systems, Autoanalyzer systems and Moored Instrumentation systems).

The National Programme in 1995 consisted of the following projects:

1. Triple B, hydrographic observations in WOCE Hydrographic Programme repeat area AR 12; project manager Dr. H.M. Van Aken (NIOZ). In a four-week cruise in the Bay of Biscay with RV 'Pelagia' from Texel to Brest (France) more than 100 CTD-rosette sampler casts were sampled, and 10 Argos surface drifters and 8 long-term current meter moorings were deployed.
2. OMEX 1995, benthic processes; project manager Dr. Tj.C.E. Van Weering (NIOZ). This cruise was executed also in the Bay of Biscay on board RV 'Pelagia' in two three-week legs. The first biological-oriented leg from Brest to La Coruña (Spain) was led by Prof. Dr. P.A.W.J. De Wilde and the second geological-oriented leg from La Coruña to Texel was led by Dr. Tj.C.E. Van Weering.
3. Anaxiprobe 1995, a two-phased project to determine the geological origin and evolution of the actively developing Anaximander Mountains in the eastern Mediterranean Sea; project leader Dr. J.M. Woodside (VU). The execution of the first phase was a nine-day cruise on board the French RV 'l'Atalante'. RV 'l'Atalante' is equipped with a dual multi-beam swath bathymetry system, seismic, magnetic and gravimetric systems. The second phase will be granted by GOA based on the results of the first phase. If approved it will be executed in 1996 on board the Russian RV 'Gelendzhik'.
4. The partial pressure of CO_2 in the South Atlantic Ocean; project manager Prof. dr. ir. H.W. De Baar (NIOZ). One scientist and one auto-analyser technician joined the German RV 'Polarstern'.
5. GLOBEC; project manager Dr. M.A. Baars (NIOZ). Three scientists joined the NOAA RV 'Malcolm Baldridge' to participate in the US Indian Ocean Programme in May and in August.

—Advice to GOA for ships of opportunity and programme 1996 and 1997:
For the execution of the 1996 programme of Triple B (project manager Dr. H.M. Van Aken) and OMEX (project manager Dr. Tj.C.E. Van Weering) MRF advised the use of RV 'Pelagia', and for the execution of Deep Chlorophyll Maximum (project manager Dr. M. Veldhuis) the RV 'Tydeman' was recommended. The Russian RV 'Gelendzhik' was proposed for the Training through Research Cruise (project manager Dr. J.M. Woodside) and for Biodiversity (project manager Dr. J. Van der Land) the use of an Indonesian ship was arranged.

For the 1997 programme, MRF advised GOA on requests for three ships of opportunity (two NIOZ and one Univ. of Utrecht) and on ten sea-going applications (five NIOZ, three Free Univ. and two Univ. of Utrecht).

M.J. Rietveld and C.N. Van Bergen Henegouw (executive secretary) took part in the 9th meeting of the International Ship Operators (chairman Alan Robertson), at the Sea Fisheries Research Institute, Cape Town, South Africa. At this meeting it was agreed that all research vessels should have Protection & Indemnity insurance, to safeguard international scientific co-operation. A proposal was accepted to organise a bi-annual marine technician workshop-training. The first workshop will be held in Southampton (UK) in October 1996.

Mr. T.F. De Bruin was contracted temporarily to set up a procedure for the on-route data collection on board the RV 'Pelagia' and to develop a data flow protocol. For that purpose study trips were made to KNMI, RIKZ and BODC (UK).

GOA requested Dr. H.M. Van Aken and C.N. Van Bergen Henegouw to represent the Netherlands academic marine research community in Euro-Goos activities, in resp. the science- and the technology-panel.

The total effort of MRF in terms of cruise, ship days and personnel involved for 1995 is given in the table.

Project	ship days	scientists	students	MRF	others
1	28	3	4	5	2
2 leg 1	21	8	-	3	2
leg 2	19	5	-	3	4
3	12	3	4	-	1
4	58	3	1	1	4
5 leg 1	28	3	-	-	-
leg 2	28	3	-	-	-

Contributors: *C.N. van Bergen-Henegouw* (Coordinator)

2. Publications and presentations

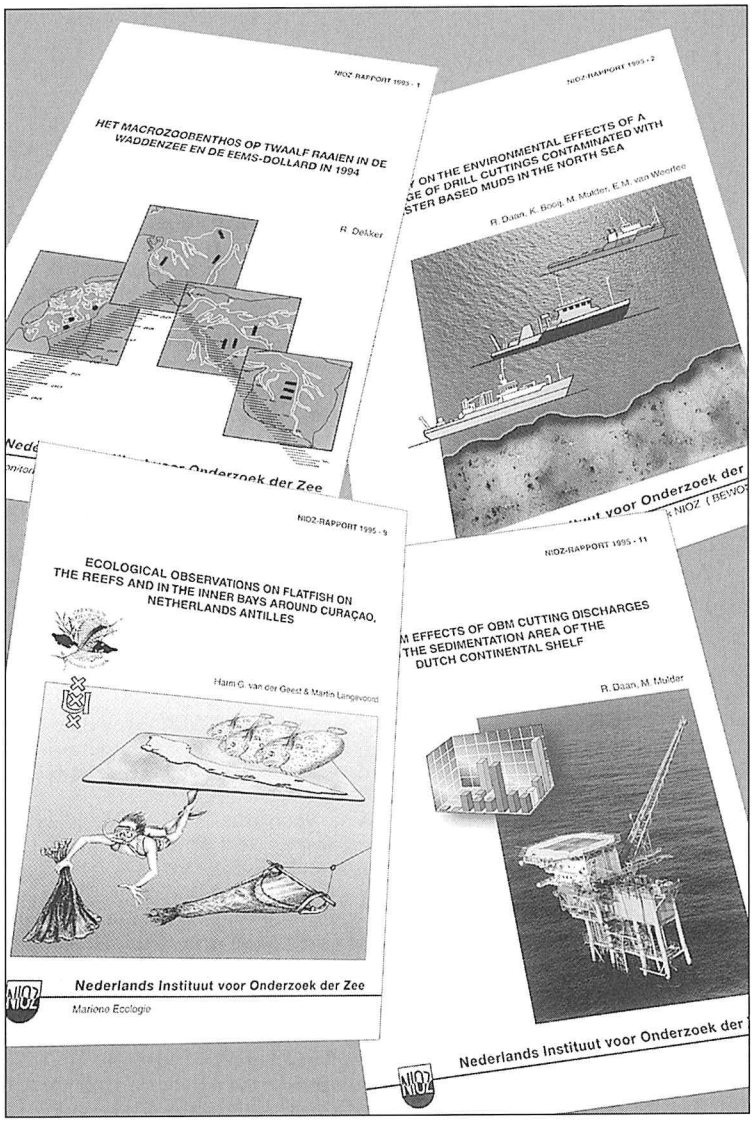


Photo: H. Hobbelink

PUBLICATIONS

NETHERLANDS JOURNAL OF SEA RESEARCH AND OTHER SERIES ISSUED

In 1995, volumes 33 and 34 of the Netherlands Journal of Sea Research appeared and no 23 of the NIOZ Publication Series (the Annual Report 1994). The Annual Report was edited by B. Bak, G.C. Cadée, P. De Wolf and H.M. Van Aken.

Among the issues of the NJSR, two were special issues, *viz.* 33 (3/4), which was devoted to the European Regional Seas Ecosystem Model (ERSEM) and edited by J.G. Baretta-Bekker, and 34 (1-3), which contained the third part of the Proceedings of the second international Symposium on Flatfish Ecology. It was edited by R. Berghahn, A.D. Rijnsdorp and H.W. Van der Veer, with the assistance of J.G. Baretta-Bekker. Regular numbers were 33 (1) (dated December 1994), 33 (2) and 34 (4).

In consultation with the Editors, the Director and Board of NIOZ decided to reorganise the editing of the NJSR. The seven editors and the 32 member Advisory Board were replaced by two editors (J.J. Beukema and G.C. Cadée) and 35 co-editors (most of them from outside The Netherlands). Starting from vol. 35, the name of the NJSR will be changed to Journal of Sea Research to stress the truly international, non-regional, character of the periodical. At the same time, the scope will be restricted to marine ecology in a wide sense, including reports on abiotic factors as far as they are relevant to the understanding of the functioning of marine ecosystems.

In contrast to the NIOZ Publication Series, the Journal is no longer available on an exchange basis.

PUBLICATIONS NIOZ 1995

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3 Bak, R.P.M., F.C. Van Duyl & G. Nieuwland. Organic sedimentation and macrofauna as forcing factors in marine benthic nanoflagellate communities.—Microb. Ecol. **29:** 173-182.

4 Bak, R.P.M. & G. Nieuwland. Long-term change in coral communities along depth gradients over leeward reefs in the Netherlands Antilles.—Bull. mar. Sci. **56:** 609-619.

5 Baltus, C.A.M. & H.W. Van der Veer. Nursery grounds of the solenette *Buglossidium luteum* (Risso, 1810) and scaldfish *Arnoglossus laterna* (Walbaum, 1792) in the southern North Sea.—Neth. J. Sea Res. **34:** 81-88.

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7 Beerens, S.P. Mixing by chaotic advection in tidal areas. Ph.D. Thesis, University of Utrecht.

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10 Beukema, J.J. & E.C. Flach. Factors controlling the upper and lower limits of the intertidal distribution of two *Corophium* species in the Wadden Sea.—Mar. Ecol. Prog. Ser. **125:** 117-126.

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13 Brussaard, C.P.D., R. Riegman, A.A.M. Noordeloos, G.C. Cadée, H. Witte, A.J. Kop, G. Nieuwland, F.C. Van Duyl & R.P.M. Bak. Effects of grazing, sedimentation and phytoplankton cell lysis on the structure of a coastal pelagic food web.—Mar. Ecol. Prog. Ser. **123:** 259-271.

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15 Cadée, G.C. Birds as producers of shell fragments in the Wadden Sea, in particular the role of the Herring gull.—Geobios M.S. **18:** 77-85.

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31 Chen, S. & D. Eisma. Fractal geometry of *in situ* flocs in the estuarine and coastal environment.—Neth. J. Sea Res. **33:** 173-182.

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Bakker, D.C.E. & H.J.W. De Baar. CO_2 air-sea exchange and skin temperature in the Southern Ocean. 3rd International Symposium on Air/Water gas transfer, Heidelberg, Germany, 26 July.

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Boon, A.R. Phytopigments and fatty acids as biomarkers of the quality of near-bottom particulate organic matter in the North Sea. ESF Congress on Significance of Coastal Seas in Global Change, Granada, 22-26 April.

Cadée, G.C. Gastropod shell repair in Cholla Bay and the role of 'habitat averaging'. 65e Jahrestagung Paläontologische Gesellschaft, Hildesheim, 24-30 September.

Camphuysen, C.J., B. Calvo, J. Durinck, K. Ensor, R.W. Furness, S. Garthe, G. Leaper, H. Skov, M.L. Tasker & C.J.N. Winter. Numbers of seabirds and their North Sea distribution in 1993/94. 5th International Seabird Group Conference, Glasgow, 24-26 March.

Camphuysen, C.J., K. Ensor, R.W. Furness, S. Garthe, O. Hüppop, G. Leaper, H. Offringa, H. Skov & M.L. Tasker. The use of discards and offal from trawlers by seabirds wintering in the North Sea. 5th International Seabird Group Conference, Glasgow, 24-26 March.

De Heij, H. Oxic, suboxic and anoxic degradation of organic matter in North Sea Sediments. ESF Congress on Significance of Coastal Seas in Global Change, Granada, 22-26 April.

De Jong, J.T.M., R.F. Nolting, B.M. Löscher & H.J.W. De Baar. Sampling and analytical methods for trace metals in seawater and their interaction with phytoplankton. International Symposium on Carbon Fluxes and Dynamic Processes in the Southern Ocean: Present and Past, Brest, 28-31 August.

De Leeuw, J.W. & H.-J. Bosch. Preliminary molecular palaeontological results of a study on Late Miocene/Early Pleistocene Mediterranean sediments. From Sedimentary Basin to Palaeo-environment. Netherlands Research School of Sedimentary Geology (NSG) Symposium, Utrecht, 26 October.

De Vreeze, A., A.J. Van Bennekom & S.J. Van der Gaast. Biogenic silica in the sediment of the NW Indian Ocean. Congress German Geological Society, Bremen, 22-25 February.

De Wilde H.P.J., M. De Bie & W. Helder. Nitrous oxide and methane in the Scheldt river and estuary. EC Research Conference on Oceanography: Significance of Coastal Seas in Global Change, Granada, Spain, 22-27 April.

De Wilde, H.P.J. & J. Duyzer. Methane emissions off the Dutch coast: Air-sea concentration differences *versus* atmospheric gradients. Third International Symposium on Air-Water Gas Transfer, Heidelberg, Germany, 24-27 July.

Dekker, R. Long-term trends in the dynamics of the bivalves *Abra tenuis* and *Tellina tenuis* in the Wadden Sea. International Conference on Long-term Changes in Marine Ecosystems, Arcachon, 1-3 February.

Everaarts, J.M. & J. Nieuwenhuize. Heavy metals in surface sediment and epibenthic macroinvertebrates from the coastal zone and continental slope of Kenya. International Conference on Marine Pollution and Ecotoxicology, Hong Kong, 22-25 January.

Ficken, K.J., H.-J. Bosch, H. Brinkhuis & J.W. De Leeuw. Long-term productivity changes and possible event related biomarkers at the K/T boundary. From Sedimentary Basin to Palaeo-environment. Netherlands Research School of Sedimentary Geology (NSG) Symposium, Utrecht, 26 October.

Ficken, K.S., H.-J. Bosch, H. Brinkhuis & J.W. De Leeuw. Long-term productivity changes and possible event related

biomarkers at the K/T boundary. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Frost, R.L., A.M. Vassalo & S.J. Van der Gaast. The dehydroxylation of the kaolinite clay minerals. Euroclay '95 conference, Leuven, Belgium, 20-25 August.
Ganssen, G.M., S.R.T.Troelstra, Tj.C.E. Van Weering & E. Bard. Quaternary paleoproductivity estimates in cores from the Somali upwelling region. Arabian Sea Workshop, NIOZ, 13-16 February.
Gast, G.J., R.P.M. Bak & F.C. Van Duyl. Microbes in coral reef waters: variation in time and space along a eutrophication gradient. Int. Workshop Aquatic Microbial Ecology, Konstanz, Germany, 17-22 April.
Gelin, F., J.S. Sinninghe Damsté, W.N. Harrison, J.R. Maxwell & J.W. De Leeuw. Variations in origin and composition of kerogen constituents as revealed by analytical pyrolysis of immature kerogens before and after desulphurization. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Hoefs, M.J.L., J.S. Sinninghe Damsté & J.W. De Leeuw. Organic Geochemistry of Arabian Sea Surface Sediments: Paleoenvironmental Implications. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Höld, I.M., S. Schouten & J.S. Sinninghe Damsté. Multiple origins of pyrolysis products of kerogens as revealed by compound-specific carbon isotope analysis. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Honkoop, P.J.C., J.J. Beukema & D. Kwast. Winter temperature and reproductive success in shell-fish in the Dutch Wadden Sea. Verwey Symposium, NIOZ, 30 January -1 February.
Jansen, J.H.F. & E. Ufkes. Late Quaternary movements of the Angola-Benguela Front and advection variations in the equatorial ocean. 5th International Conference on Paleoceanography, Halifax, Canada, 10-14 October.
Kok, M.D., S. Schouten & J.S. Sinninghe Damsté. Laboratory simulation of some functionalized model compounds and the catalytic influence of sediment. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Koopmans, M.P. Molecular palaeontological evidence for photic zone anoxia in past depositional environments. Verwey Symposium, NIOZ, 30 January-1 February.
Köster, J., M. Rospondek, A. Zubrzycki, M. Kolouba, J.W. De Leeuw & J.S. Sinninghe Damsté. A molecular organic geochemical study of black shales associated with diatomites from the Oligocene Menilite Shale (Flysch Carpathians, SE Poland). 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Köster, J., S. Schouten, J.S. Sinninghe Damsté & J.W. De Leeuw. Reconstruction of the depositional environment of Toarcian marlstones (Allgäu Formation, Tyrol / Austria) using biomarkers and compound specific carbon isotope analysis. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Kühnel, R.A. & S.J. Van der Gaast. Effects of sample preparation for XRD analysis on mineralogical composition of rocks: case study on clay minerals in basaltic rocks. Euroclay '95 conference, Leuven, Belgium, 20-25 August.
Löscher, B.M., J.T.M. De Jong, F. Dehairs & H.J.W. De Baar. Particulate trace metal distributions in and between the Polar Front and the Marginal Ice Zone. SO-JGOFS Symposium, Brest, 28-31 August .
Mensink, B.P., J.M. Everaarts, H. Kralt, C.C. Ten Hallers-Tjabbes & J.P. Boon. Tributyltin (TBT) exposure in early life stages induces the development of male sexual characteristics in common whelks, *Buccinum undatum*. 8th Symposium on Pollutant Responses in Marine Organisms, Pacific Grove, California, 2-5 April.
Nolting, R.F., T.J.W. Happee & W. Helder. Behaviour of trace- and major elements in sediments in an upwelling zone of the Somalia and Oman continental margin and the Equatorial Indian Ocean. Arabian Sea Workshop, NIOZ, 13-16 February.
Noordeloos, A.A.M., R. Riegman & I. Flameling. Size-differential 14C and 15N uptake by phytoplankton in the North Sea. EC MAST Advanced Study Course on Marine Flow-Cytometry, Theory and application to Ocean Processes. Plymouth, 16-29 July.
Peulvé, S., J.D.H. Van Heemst, J.W. De Leeuw, W. Klein Breteler, M.-A. Sicre & A. Saliot. Preservation of organic matter during water column transport. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Philippart, C.J.M., J.J. Beukema, G.C. Cadée, H.J. Lindeboom, J. Van der Meer & A.F. Zuur. Parallel long-term changes in air pressure, zoobenthos and Eider fledglings. International Conference on Long-term Changes in Marine Ecosystems, Arcachon, France, 1-3 February.
Pool, W.G., J.W. De Leeuw & B. Van de Graaf. Automated processing of GC/MS data by a repetitive backfolding of the first differential. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Riegman, R., M.N. De Boer & L.N. de Senerpont Domis. Competition experiments with toxic algae at different growth rate limiting conditions. Seventh International Conference on Toxic Phytoplankton. Sendai, Japan, 12-16 July.
Rowland, S.J., A.T. Revill, K.V. Thomas, M. Baas, C. Largeau, J.W. De Leeuw, M. Hodges, P. Lyne & C. Smith. Unresolved complex mixtures of hydrocarbons in oils: origins and characterization. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Schoemann, V., H.J.W. De Baar, J.T.M. De Jong & C. Lancelot. Controlling mechanisms of Mn seasonal distribution in the continental coastal zone of the North Sea. European Research Conference on Natural waters and water technology : Modelling of Properties and Processes in Aquatic Systems, Lenggries, 3-8 November.
Schouten, S., A. Dijkhuizen, J.S. Sinninghe Damsté, R. Wagner, H. Visscher & J.W. De Leeuw. Distribution and stable carbon isotopic composition of lipids in leaves of the birch *Betula pubescens*. Workshop Plant Taphonomy, NIOZ, 11 November.
Sinninghe Damsté, J.S., F. Kenig, F. Gelin, N. Frewin, J.M. Hayes, W.N. Harrison, J.R. Maxwell & J.W. De Leeuw. Molecular indicators of palaeoenvironmental change in a Messinian evaporitic sequence (Vena del Gesso, Italy). 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.

Tahey, T. & G.C.A. Duineveld. Benthic O_2 respiration, fauna and phytopigments in the Indian Ocean. NIOP Workshop, NIOZ, 13-14 February.

Ufkes, E., J.H.F. Jansen & R.R. Schneider. Zonal movements of the Benguela Current and Agulhas rings system during the last 420000 years: a record of left coiled *N. pachyderma* in sediments from Walvis Ridge (SE Atlantic). Annual meeting of the Netherlands Research School of Sedimentary Geology, Utrecht, 26 October.

Van Bergen, P.F., P. Moerkerken, P.J. Barrie, M.E. Collinson & J.W. De Leeuw. Sporopollenin revisited. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.

Van der Gaast, S.J., W. Frankema, Thu Ha Thi Tran & R.L. Frost. Dehydroxylation steps of kaolinite and dickite: an XRD and DTA study. Euroclay '95 conference, Leuven, Belgium, 20-25 August.

Van Duin, A.C.T., J.M.A. Baas, B. Van de Graaf, T.M. Peakman, J.W. De Leeuw & J.S. Sinninghe Damsté. Application of computational methods in predicting kinetics of diagenetic reactions: The diagenesis of 5α-cholest-7-ene. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.

Van Iperen, J.M., G.J.A. Brummer & A.J. Van Bennekom. Diatoms in sediment traps off Somalia and in surface sediments off Somalia and southern Arabia. Arabian Sea workshop, NIOZ, 13-16 February.

Van Kaam-Peters, H.M.E., S. Schouten, S.J. Van der Gaast, J.W. De Leeuw & J.S. Sinninghe Damsté. The Kimmeridge Clay Formation: Biomarker and molecular stable carbon isotope analysis. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.

Van Kaam-Peters, H.M.E. Sulphur-bound biomarkers in sediments of a Kimmeridgian palaeolagoon (French Southern Jura). Verwey Symposium, NIOZ, 30 January-1 February.

Van Weering, Tj.C.E., S. Van den Brenk & G.J.A.Brummer. Sediment dynamics of the Somali Basin continental margin, NW Indian Ocean. Arabian Sea Workshop, NIOZ, 13-16 February.

Van Weering, Tj.C.E. OMEX Benthic Boundary Layer Dynamics. 2nd Workshop EU Exchange Processes at the Continent/Ocean Margins in the North Atlantic, Knokke, 22-24 February.

Van Weering, Tj.C.E. & T. Nielsen. Development of Norwegian Sea Deep Water flow; seismic evidence from the Faeroe margin. 1st Nordic Marine Sciences Meeting, Göteborg, 23-26 March.

Van Weering, Tj.C.E. & H. de Stigter. Recent sedimentation and benthic boundary layer dynamics at the NE Biscay margin. 2nd MAST days and Euromar Market, Sorrento, 7-11 November.

Van Weering, Tj.C.E. Cold seeps at plate boundaries. Workshop on east Indonesian plate tectonic history, Free University Amsterdam, 18-19 December.

Versteegh, G., R. Riegman, J.W. De Leeuw & J.H.F. Jansen. Effects of growth limitation on the Uk_{37} alkenone ratio. An example from *Isochrysis galbana* cultures. 5th International Conference on Paleoceanography, Halifax, Canada, 10-14 October.

Veth, C. The structure of the upper layers of the Antarctic Circumpolar Current. Symposium on Carbon Fluxes and Dynamic Processes in the Southern Ocean: Present and Past. Brest, 28-31 August.

Walker, P.A. & H.J.L. Heessen. Long-term Changes in Ray Populations in the North Sea at Long-term Changes in the North Sea Ecosystem and their Causes. ICES Symposium Århus 1975 Revisited, Århus, Denmark, 11-15 July.

Wiebinga, C.J. & H.J.W. De Baar. Dissolved Organic Carbon in the Indian sector of the Southern Ocean (ANTARES). JGOFS Symposium, Villefranche, 8-12 May.

Wiebinga, C.J. & H.J.W. De Baar. Vertical distribution of Total and Dissolved Organic Carbon in the Indian sector of the Southern Ocean (ANTARES 2, summer 1994). SO/JGOFS symposium, Brest, 28-31 August.

ORAL PRESENTATIONS

Baars, M.A. The biological oceanography of the northwestern Indian Ocean: facts, myths, paradoxes and puzzles. Colloquium Institut für Meereskunde, University of Kiel, 13 January.

Baars, M.A. Productivity and plankton of the Arabian Sea. Second Int. Conference on Pelagic Biogeography, Noordwijkerhout, 11 July.

Baars, M.A. Dutch biological oceanography: Examples of approaches to understanding pelagic ecosystems. Oprichtingsdag Platform Mariene Levenswetenschapppen, KNAW, Amsterdam, 15 September.

Baars, M.A., P.H. Schalk & M.J.W. Veldhuis. An overview of NIOP-Project B Monsooons and pelagic systems. Seasonal fluctuations in plankton biomass and productivity in the Somali Current, Gulf of Aden and southern Red Sea. Arabian Sea Workshop, NIOZ, 14 February.

Baars, M.A., S.S. Oosterhuis, S.L. Smith & P.V.Z. Lane. Abundance and depth distribution of the upwelling copepod *Calanoides carinatus* in the northwestern Indian Ocean during the monsoons of 1992-1993. Arabian Sea Workshop, NIOZ, 16 February.

Baars, M.A., S.S. Oosterhuis & I. Prusova. On the paradox of low chlorophyll - high zooplankton biomass outside the upwelling season in the western Arabian Sea. Arabian Sea Dynamics, Plymouth, 19 December.

Bak, R.P.M. Tropical Marine Biology. Lecture series, University of Amsterdam, February.

Bak, R.P.M. Ecological processes in coral reefs. Lecture series, University of Marseille, October.

Bak, R.P.M. Coral diversity, populations and ecosystem functioning. Invited lecture 6th Int. Congress on Coelenterate Biology, Noordwijk, 18 July.

Bakker, D.C.E. The role of the oceans in the global carbon budget. Excursion Van Hall Institute, NIOZ, 24 April.

Bakker, D.C.E. The role of the oceans in the global carbon budget. Geochemische Kring, Utrecht, 11 May.

Bakker, D.C.E. CO_2 air-sea exchange and skin temperature in the Southern Ocean. 3rd International Symposium on Air/Water Gas Transfer, Heidelberg, 26 July.

Beerens, S.P. Chaotic mixing in the Wadden Sea. KNMI, 11 May, and NIOZ, 12 October.

Beerens, S.P. Chaotic Mixing in Tidal Eddy Fields. IAPSO'95, Honolulu, 10 August.

Bergman, M.J.N. Effects of beamtrawl fisheries on bottom fauna. Lecture course Oceanography, NIOZ, 23 March.

Bergman, M.J.N. Environmental effects of beamtrawl fisheries. BEON thematic day, The Hague, 18 May.

Bergman, M.J.N. The IMPACT-II field studies in 1994 and an improved set-up for the 1995-studies. Annual meeting IMPACT-II, Conwy, UK, 18 January.

Bergman, M.J.N. Effects of drilling operations for exploration of gas in the coastal zone of the North Sea (NAM-MER). The Hague, 26 September, and Assen, 21 December.

Bergman M.J.N. Effects of trawl fisheries on the benthic fauna in the southern North Sea. Oceanografendag, The Hague, 1 November.

Boon, J.P. PCB patterns in different species of fish-eating mammals in relation to uptake from food and biotransformation capacity. Plenary lecture at the annual meeting of the ICES Marine Chemistry Working Group, Reykjavik, Iceland, 3-7 April.

Boon, J.P. Environmental Chemistry of Organic Microcontaminants. Lecture Course on the Marine Environment, University of Groningen, 15 May.

Boon, J.P. Bioavailability of chlorobiphenyl congeners to marine mammals. Advanced post doctoral course on Sorption and Bioavailability, Research School M&T, Agricultural University Wageningen, 19 May.

Boon, J.P. The use of *in vitro* assays to investigate the role of biotransformation in the bioaccumulation of polyhalogenated organic contaminants in marine mammals and birds. Institute für Meereskunde, University of Kiel, Germany, 10 August.

Brinkhuis, H., J. Smit, K. Ficken, J.W. De Leeuw, T.B. Roep, H. Vonhof, A.J.T. Romein, J.W.M. Jagt, W.M. Felder, C. Langereis, G. Klaver, H. Willems, E. Robin & R. Rocchia. The Geulhemmerberg K/T boundary section: a window on post K/T recovery in a shallow marine setting. Annual Assembly Tethyan and Boreal Cretaceous, IGCP project nr. 362, Maastricht, 17-18 September.

Brummer, G.J.A., S. Van den Brenk & A.J. Van Bennekom. Monsoonal upwelling off eastern Yemen. Arabian Sea Workshop, NIOZ, 13-16 February.

Brummer, G.J.A., A.T.C. Broerse, S.M.H. Conan, H.T. Kloosterhuis & W. Helder. Monsoonal sedimentation in the Somali upwelling system (June 1992-February 1993). Arabian Sea Workshop, NIOZ, 13-16 February, and Institut für Meereskunde, University of Kiel, 24 May.

Cadée, G.C. Diversity and primary production of benthic plants. Course Introduction Marine Sciences NIOZ, NIOZ, 23 November.

Camphuysen, C.J., B. Calvo, J. Durinck, K. Ensor, R.W. Furness, S. Garthe, G. Leaper, H. Skov, M.L. Tasker & C.J.N. Winter. The use of discards and offal from trawlers by seabirds in the North Sea. 5th International Seabird Group Conference, Glasgow, 24-26 March.

Camphuysen, C.J. Seabirds and marine mammals of the Arctic - an introduction. Vogelwerkgroep Alkmaar, 12 April.

Camphuysen, C.J. Seabirds in the North Sea. Vogelwerkgroep Het Gooi, 26 October.

Daan, R. & M. Mulder. On the short- and long-term impact of drilling activities in the Dutch sector of the North Sea. ICES Symposium on Changes in the North Sea Ecosystem and their Causes: Århus 1975 revisited. Århus, Denmark, 11-14 July.

De Baar, H.J.W. Lecture series Introductory Oceanography. Department of Marine Biology, University of Groningen, 7-18 February.

De Baar, H.J.W. Lecture series on Rare Earth Elements and their Isotopes in the Marine Environment, Free University, Amsterdam, 9 March.

De Baar, H.J.W. The effect of iron limitation and sea-surface skin temperature on air-sea exchange of carbondioxide in the Southern Ocean. Invited keynote lecture, IGBP-SCOR-JGOFS First International Scientific Symposium, Villefranche, 9 May.

De Baar, H.J.W. Pollutant metals; greenhouse gases. Lecture series in course Marine Environment, University of Groningen, 22-23 May.

De Baar, H.J.W. Historical concepts of nutrient limitation in marine ecology. Invited lecture series, Graduate school summer course, University of Tromsø, Norway, 24-25 August.

De Baar, H.J.W. The role of iron limitation in the Southern Ocean. Invited keynote lecture, Symposium on Carbon Fluxes and Dynamic Processes in the Southern Ocean, Brest, 28-31 August.

De Baar, H.J.W. The role of the oceans in climate change. Studium Generale, Leiden University, 12 October.

De Leeuw, J.W., F. Gelin & J.S. Sinninghe Damsté. Selective preservation of organic matter in the marine environment: where are we? 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.

De Wilde H.P.J. Upwelling off Somalia induces high N_2O emissions into the atmosphere. Arabian Sea workshop, NIOZ, 13-16 February.

De Wilde, P.A.W.J. Challenges and perspectives in marine ecolgical research. KNAW Symposium, Amsterdam, 17 February.

De Wilde, P.A.W.J. Seasonal variation in O_2 uptake, phytodetritus content and benthic biomass of the sediments across the Goban Spur. OMEX Workshop, Knokke, 22-24 February.

De Wilde, P.A.W.J. The ecosystem of the North Sea: an introduction. DiS Study Tour to Holland - NIOZ Course. NIOZ, 16 October.

De Wilde, P.A.W.J. Structure and functioning of the southern North Sea. Marine Environment Course, Van Hall Institute, Groningen, 7 December.

Duineveld, G.C.A. Benthic metabolism on the Kenyan shelf and slope. NIOP - Kenya Workshop, Mombasa, 28-31 March.

Duineveld, G.C.A. Patterns in benthic activity and biomass in the Cretan Sea. CINCS Workshop, Crete, 18-19 September.

Eisma, D. Lecture series Marine Sedimentology. University of Utrecht, 1 January-9 February.

Eisma, D. Sedimentation in the Wadden Sea. Wadden Sea Course, NIOZ, 28 April.

Eisma, D. Flocculation of suspended matter. Kiel University, 12 May.

Eisma, D. Fine-grained coastal and shelf sediments. Post-Doc Course, University of Copenhagen, 25-27 August.

Everaarts, J.M. DNA integrity as a biomarker of marine pollution: strand breaks in seastar (*Asterias rubens*) and dab (*Limanda limanda*). International Conference on Marine Pollution and Ecotoxicology, Hong Kong, 22-25 January.

Everaarts, J.M. Introduction to toxicology. Course Marine Environment, University of Groningen, 16 May.

Everaarts, J.M. PCBs and pesticides in the tropical marine environment: field studies and laboratory experiments. Second research Coordination Meeting of the IAEA CRP on the Distribution, Fate and Effects of Pesticide Residues on Biota in Tropical Marine Environments: Use of radiotracers. Kuala Lumpur, Malaysia, 12-16 June.

Everaarts, J.M. Molecular biomarkers of marine pollution. Ocean Forum, National Institute of Oceanography, Goa, India, 2 August.

Everaarts, J.M. Biomarkers of marine environmental contamination. National Institute of Oceanography, Regional Centre, Cochin, India, 11 August.

Ficken, K.J., H.-J. Bosch, H. Brinkhuis, J.W. De Leeuw & H. Visscher. Biogeochemistry of the Cretaceous/Tertiary boundary. 4th International Workshop of the ESF Scientific Network on Impact Cratering and Evolution of Planet Earth, Ancona, Italy, 12-17 May.

Fonds, M. Short- and long-term changes in the fish fauna of the Wadden Sea. Meeting Society for the Protection of the Wadden Sea (Waddenzee Vereniging), Den Helder, 28 October.

Fonds, M. Effects of beamtrawl fishery on North Sea benthos. Annual meeting Deutsche Fischerei Verein, Busum, 16 November.

Fransz, H.G. The identification of relevant functional units and processes. Course Graduate School of Functional Ecology, NIOZ, 3 April.

Fransz, H.G. Introduction to modelling approaches and techniques. Course Graduate School of Functional Ecology, NIOZ, 3 April.

Fransz, H.G. Modelling copepod population dynamics in the Southern Ocean. Course Graduate School of Functional Ecology, NIOZ, 7 April.

Fransz, H.G. Models and the marine environment. Course Marine Environment, University of Groningen, 23 May.

Ganssen, G.M., S.R.T. Troelstra, Tj.C.E. Van Weering & E. Bard. Quaternary paleoproductivity estimates in cores from the Somali upwelling region. Arabian Sea Workshop, NIOZ, 13-16 February.

Gonzalez, P.M. & T. Piersma. Food and feeding of Knots on their staging areas in Patagonia (Argentina). 10th International Waterfowl Ecology Symposium, IWRB/WSG, Aveiro, Portugal, 18 September.

Hansen, F.C., H.J. Witte & J. Passarge. Selective grazing in the dinoflagellate *Oxyrrhis marina*. SLW discussion group zooplankton FRIENDS, Nieuwersluis, 19 May.

Helder, W. Early diagenesis in sediments from the oxygen minimum zone of Yemen. Arabian Sea Workshop, NIOZ, 13-16 February.

Helder, W. Cycling of of phosphorus and nitrogen in marine sediments. Course Graduate School of Functional Ecology, Yerseke, 14 March.

Helder, W. Mineralization of organic debris in sediments of the Goban Spur area. OMEX Benthic Boundary Layer Dynamics. 2nd Workshop EU Exchange Processes at the Continent/Ocean Margins in the North Atlantic, Knokke, 22-24 February.

Helder, W. Mechanisms of organic matter preservation mechanisms. GOA presentatiedagen, Earth Sciences, University of Utrecht, 10 November.

Hillebrand, M.Th.J. Are we producing reliable and valuable data? Introduction of Quality Assurance (QA) and Quality Control (QC) procedures. Workshop Gradients in the Sea; an integrated oceanographic study of Pattani Bay and the adjacent part of the Gulf of Thailand, Pattani, 15-29 March.

Hoefs, M.J.L., J.S. Sinninghe Damsté & J.W. De Leeuw. Methanogens and diatoms as sources of sedimentary organic matter in Recent Indian Ocean sediments, Arabian Sea Workshop, NIOZ, 13-16 February.

Jansen, J.H.F. Milankovic and the South Atlantic Ocean, or other times, other glacials. Klimaatdag Kon. Ned. Geol. Mijnbouwk. Gen. en Kring voor Toegepaste Fysische Geografie. Space Expo, Noordwijk, 8 April.

Klein Breteler, W.C.M. Estimating the cell volume of microorganisms using 2-D microscope images. Quantimet gebruikersgroep, Amsterdam, 9 November.

Kok, M., S. Schouten & J.S. Sinninghe Damsté. Laboratory simulation of natural sulphurization: The catalytic influence of sediment. Verwey-Symposium, NIOZ, 30 January-1 February.

Koopmans, M.P., J.S. Sinninghe Damsté, W.I.C. Rijpstra, M.D. Lewan & J.W. De Leeuw. Impact of dia- and catagenesis on sulphur sequestration of biomarkers in sediments as revealed by artificial maturation. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 8 September.

Koopmans, M.P., M.D. Lewan, J.S. Sinninghe Damsté & J.W. De Leeuw. Low temperature (T<280 °C) hydrous and anhydrous pyrolysis of immature sulphur-rich sedimentary rocks. Workshop Interfaces of Geochemistry, Irvington VA, USA, 16 May.

Kuipers, B.R. Boundary conditions and planktonic foodweb structure. ICES Symposium on Changes in the North Sea Ecosystem and their Causes: Århus 1975 revisited. Århus, Denmark, 11-14 July.

Kuipers, B.R. Plankton communities of the North Sea. DiS Study Tour to Holland-NIOZ course, NIOZ, 16 October.

Lancelot, C. & C. Veth. Does the circumpolar marginal ice zone contribute significantly to Southern Ocean biogeochemical cycles? Symposium on Carbon Fluxes and Dynamic Processes in the Southern Ocean: Present and Past, Brest, 28-31 August.

Lindeboom, H.J. Scientific research in areas closed to fisheries. BEON thematic day, RIKZ, The Hague, 18 May.

Lindeboom, H.J. Marine models as tools for research and management. Course Graduate School of Functional Ecology. NIOZ, 3 April.

Lindeboom, H.J. Sudden changes in marine ecosystems, effects of weather and oceans underestimated? Workshop on ECNASAP, Halifax, 21 April.

Lindeboom, H.J. Biotic research in Banten Bay, Indonesia. Workshop on Indonesian-Netherlands Teluk Banten project, Jakarta, 1 May.

Lindeboom, H.J. Changes in marine ecosystems: possible influences of climate and implications for the natural and social sciences. Workshop on Priority Programme, NIOZ, 12 June.

Lindeboom, H.J. Trends in the large North Sea ecosystem, implications for management. Workshop The Sea as a Large Marine Ecosystem, RIKZ, The Hague, 14 June.

Lindeboom, H.J. Ecological research in the coastal area of the North Sea and implications for possible drilling strategies. NAM-workshop MER Nederlandse kustzone en Ameland, Assen, 4 July.

Lindeboom, H.J. (Sudden) changes in marine ecosystems: climate and oceanic influences underestimated? EERO-workshop Changing Estuarine and Coastal Environments, Geesthacht, 11 October.

Lindeboom, H.J. To eat and to be eaten in the North Sea. Calamari Symposium '95, Groningen, 21 October.
Lohse, L. Denitrification rates as measured by the isotope pairing method and by the acetylene inhibition technique in continental shelf sediments of the North Sea. International workshop on microbial ecology, Konstanz, Germany, 19 April.
Löscher, B.M. Fe in the Southern Ocean - its relationship to hydrography and biology. Verwey Symposium, NIOZ, 30 January-1 February.
Maas, L.R.M. Geometric focusing of internal waves. University of Victoria, British Columbia, 13 January.
Maas, L.R.M. Scattering properties of linear waves over topography in homogeneous and stratified fluids. Aha Huliko'a conference, Honolulu, 19 January.
Maas, L.R.M. A simple model of the three-dimensional, thermally and wind-driven ocean circulation. KNMI, 16 March.
Maas, L.R.M. & G. Van der Schrier. Chaos in a simple model of the thermohaline circulation. EGS meeting Hamburg, 3 April.
Maas, L.R.M. Geometric focusing of internal waves. EGS meeting Hamburg, 7 April.
Maas, L.R.M. On a two-dimensional map related to the Lorenz equations, IMAU, University of Utrecht, 27 June.
Maas, L.R.M. & F.-P.A. Lam. Geometric focusing of internal waves. NWO prioriteits programma conferentie over Nietlineare systemen: Nonlinear aspects of wave-generation and wave-interaction, Kijkduin, 1 September.
Maas, L.R.M. & F.-P.A. Lam. Geometric focusing of internal waves. Euromech conference no 339 on Internal Waves, Turbulence and Mixing in Stratified Flows, Lyon, 6-9 September.
Maas, L.R.M. Geometric focusing of internal waves. Ecole Normale et Superieure de Lyon, 10 October.
Maas, L.R.M. & F.-P.A. Lam. Geometric focusing of internal waves. NIOZ, 26 October.
Mensink, B.P. Tributyltin laboratory experiments with common whelks and field observations. Colloquium Rijksinstituut voor Kust en Zee, Haren, 5 October.
Osinga, R., A.J. Kop & F.C. Van Duyl. Effects of the sea urchin *Echinocardium cordatum* on bacterial production in experimental benthic systems under increasing organic loading. Int. Workshop Aquatic Microbial Ecology, Konstanz, Germany, 19 April.
Osinga, R. & J.J. Minnaard. The fate of DMSP after deposition of DMSP containing microalgae on marine sediments. First International Symposium on DMSP and related sulfonium compounds, Mobile, Alabama, 7 June.
Philippart, C.J.M. Tropical seagrass ecosystems. Lecture series Tropical Marine Biology, University of Amsterdam, 24 January.
Philippart, C.J.M., J.J. Beukema, G.C. Cadée, H.J. Lindeboom, H.M. Van Aken, J. van der Meer, H.W. van der Veer & J.IJ. Witte. Long-term fluctuations of fish recruits and their environment in the western Wadden Sea. ICES Symposium on Changes in the North Sea Ecosystem and their Causes: Århus revisited, Århus, Denmark, 11-14 July.
Piersma, T. Documentary film on the Swedish-Russian Tundra Ecology Expedition 1994, Swedish National Television, 12 March.
Piersma, T. A researcher on the edge. Verwey-lecture Verwey Symposium, NIOZ, 31 January.
Piersma, T. Evolutionary dynamics in ecophysiological adaptations. Invited presentation at Symposium on Adaptation mechanisms in Animal Physiology, Berg en Dal/Nijmegen, 1 December.
Piersma, T. Long-distance migrating waders and Texel. Jozefschool, Den Burg, 13 October.
Piersma, T. The migration of waders and the role of the Wadden Sea. IVN, Den Burg, Texel, 30 October.
Piersma, T. Timing of migration. Thematic day on behaviour in a fluctuating environment, Netherlands Ornithological Union, University of Groningen, 11 February.
Piersma, T. Why a food specialist must be a migrant. Thematic day on Bird Migration, Netherlands Ornithological Union, University of Amsterdam, 22 April.
Piersma, T. Does a sensory specialism drive the evolution of long-distance migration and associated ecophysiological and behavioural adaptations in knots? Summer Meeting of the Association for the Study of Animal Behaviour, Leiden, 14 July.
Piersma, T. Evolutionary energetics of long-distance migration in shorebirds. Invited Christmas Lecture at the Applied Ecology Unit, Department of Biology, University of Glasgow, Scotland, 8 December.
Piersma, T. Making reproductive investments half a world away from home (the case of high arctic breeding shorebird). Symposium SLW/NEDECOL, Wageningen, 15 December.
Piersma, T. Series of three lectures on ecology and energetics of migratory shorebirds. Undergraduate Course on Ornithology, Van der Klauw Laboratory, University of Leiden, 27 September.
Piersma, T. Shorebird flyways and conservation in Europe and Africa. Keynote-speech, Workshop Towards a Shorebird Action Plan for the Americas, Wetlands for the Americas, Canadian Museum of Nature, Ottawa, Canada, 11 May.
Piersma, T. Shorebird migration in Europe and Africa: conservation implications of pure scientific research. Thematic evening on Waterbird Migration, Landelijke Vereniging tot Behoud van de Waddenzee, Harlingen, 26 May.
Piersma, T. Wader birds (Knots). DiS Study Tour to Holland-NIOZ course, NIOZ, 18 October.
Piersma, T. Waders and benthic macrofaunal populations: the evolutionary arms race. Lecture for AIO Autumn School, NIOZ, 22 November.
Piersma, T. Waders in tropical wetlands. Lecture Course on Tropical Marine Ecology, University of Amsterdam, 19 January.
Ridderinkhof, H. Chaotic advection in tidal current fields: application to dispersion in realistic numerical models. IAPSO XXI General Assembly, Honolulu, USA, 10 August.
Riegman, R. A modelling approach on harmful algal blooms. Post-Conference Seventh International Conference on Toxic Phytoplankton, Kyoto, Japan, 12-16 July.
Riegman, R. Impact of eutrophication on pelagic foodweb structure and functioning. Course Graduate School of Functional Ecology, NIOZ, 5 April.
Ruardij, P. The ERSEM-moe: the actual state and future application. Beleidspresentatie BEON, The Hague, 31 March.
Ruardij, P. Introduction to ERSEM. Marine Ecological Modelling course, NIOZ, 3-7 April.

Ruardij, P. Benthic nutrient regeneration in the ERSEM ecosystem model of the North Sea. Marine Ecological Modelling course, NIOZ, 3-7 April.
Ruardij, P. Modelling vertical fluxes in the North Sea. NIRE, Tsukuba, Japan, 21 November.
Ruardij, P. Modelling vertical fluxes in the North Sea for environmental engineers, Tokyo, Japan, 22 November.
Ruardij, P. Modelling vertical fluxes in the North Sea. Fishery Research Station of Aichi Prefecture, Aichi, Japan, 24 November.
Ruardij, P. INP mooring: Modelling the impact of stratification. Phytoplankton Production and Distribution Modelling Committee EU, The Hague, 15 December.
Schouten, S., A. Dijkhuizen, J.S. Sinninghe Damsté, R. Wagner, H. Visscher & J.W. De Leeuw. Stable carbon isotope analysis of lipids in recent and fossil leaves of the birch *Betula pubescens*. ACS Symposium, Chicago, 20-24 August.
Schouten, S., M. Schoell, W.I.C. Rijpstra, J.S. Sinninghe Damsté & J.W. De Leeuw. Recognition of regional variations in the depositional environment of the Monterey formation by compound specific isotope analysis. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4 September.
Schouten, S., J.S. Sinninghe Damsté, M.J.L. Hoefs & J.W. De Leeuw. Distribution and carbon isotopic compositions of sedimentary methanogenic ether lipids, ACS symposium, Chicago, 20-24 August.
Sinninghe Damsté, S.J. Assessment of photic zone anoxia in past depositional environments by molecular fossils: Application to the Cenomanian/Turoninan oceanic anoxic event. University of Kiel, 6 November.
Sinninghe Damsté, S.J. Marine biogeochemisty. Bezoek vaste 2e kamercommissie voor onderwijs en wetenschap aan NWO, Scheveningen, 29 September.
Sinninghe Damsté, S.J. Marine biogeochemistry. Verwey Symposium, NIOZ, 30 January.
Sinninghe Damsté, J.S., M.P. Koopmans, H.M.E. Van Kaam-Peters, F. Kenig, J. Köster, S. Schouten & J.W. De Leeuw. Molecular palaeontological evidence for photic zone anoxia in past depositional environments. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4 September.
Smit, J., T.B. Roep, W. Alvarez, P. Claeys, A. Montanari, J.W. De Leeuw, K. Ficken & H. Brinkhuis. Impact related K/T extinctions and radiations: Where do we stand? 4th International Workshop of the ESF Scientific Network on Impact Cratering and Evolution of Planet Earth, Ancona, Italy, 12-17 May.
Spaargaren, D.H. Lecture series on shrimp aquaculture. Wanning, Hainan prov., P.R. China, October-November.
Ten Hallers-Tjabbes, C.C. Efficacy and implementation of early warning signals in policies for dredged materials. London Convention Scientific Group. Meeting of Ad Hoc Group of Experts on dredged Materials, Los Angeles, 23-27 January.
Ten Hallers-Tjabbes, C.C. Effects of organotin antifoulants in relation to international protective policies. Workshop Antifouling paints for marine shipping, Ministry of Public Housing, Physical Planning and the Environment & Directorate General for Shipping, The Hague, 21 February.
Ten Hallers-Tjabbes, C.C. & B.P. Mensink. Imposex at the North Sea. Noorderlicht scientific series, Dutch Television, 9 April.
Ten Hallers-Tjabbes, C.C. Marine science in marine environmental policies; case studies. Course on Marine Environment, University of Groningen & Van Hall Institute, 8 May.
Ten Hallers-Tjabbes, C.C. (for IUCN). TBT in harbour dredge spoil discharged in the marine environment. London Convention Scientific Group 18 (LC/SG 18), 10-14 July.
Ten Hallers-Tjabbes, C.C (for IUCN). Improving efficacy of early warning signals about adverse events in the marine environment. London Convention Scientific Group 18 (LC/SG 18), 10-14 July.
Ten Hallers-Tjabbes, C.C. Why is the whelk disappearing from the North Sea? RIKZ, Haren, 5 October.
Ten Hallers-Tjabbes, C.C. Organotins, Ecotoxicological effects and policies. Lecture series for students Van Hall Institute, 21 September and 23 November.
Ten Hallers-Tjabbes, C.C. Impact of traditional antifouling in open sea. Risk and ecological consequences. Conference on cost *vs* benefits of TBT alternative antifoulants, Euromediterranean Centre on Insular Coastal Dynamics, Malta, 4-6 December.
Van Aken, H.M. Eddy transport across the Arctic Frontal Zone in the Greenland Sea. Symposium Nordic Seas on the results from the Greenland Sea Project, Hamburg, 8 March.
Van Aken, H.M. Chemical and physical characteristics of Subpolar Mode Water in the north-eastern North Atlantic. Meereskundlichen Kolloquium, Institut für Meereskunde, University of Kiel, 17 November.
Van Bennekom, A.J. Distribution of low oxygen concentrations in the Indian Ocean. Institut für Meereskunde, University of Kiel, 13 January.
Van Bennekom, A.J., M.A. Hiehle, G.W. Kraay & C.H. Van der Weijden. Overview deep hydrography NIOP legs B, C, D with emphasis on oxygen distribution: Highlights, surprises and puzzles. Arabian Sea Workshop, NIOZ, 16 February.
Van Bennekom, A.J. & J.E.E. Van Beusekom. Influence of aluminium on the biogeochemical silica cycle. School of Earth & Atmospheric Sciences, Georgia Tech, Atlanta, 18 October.
Van Bergen, P.F., M.E. Collinson & J.W. De Leeuw. Preservation of resistant plant biomacromolecules. EUG 8, Strasbourg, Germany, 9-13 April.
Van Bergen, P.F., R.P. Evershed, M.E. Collinson & J.W. De Leeuw. Desiccation, a different type of fossilization? Macromolecular constituents of propagule walls as a test case. BOGS '95, Bristol, UK, 12-13 July.
Van der Meer, J. Sampling surveys in fisheries studies. Workshop Statistical analysis of sample surveys, RIVO, IJmuiden, 24 April.
Van der Meer, J. Interference and the spatial distribution of wintering waders. Workshop Oystercatchers on the shore, IBN, Texel, 26 April.
Van der Meer, J. Alternative methods for imputing missing bird counts as applied in the Netherlands. 10th International Waterfowl Ecology Symposium, Aveiro, Portugal, 19 September.
Van der Meer, J. The pros and cons of multivariate direct gradient analysis as a tool to predict the effect of habitat change on marine benthos. Lectures in aquatic ecology, IBN, Texel, 10 October.
Van der Meer, J. Multivariate methods to relate animal species to their environment: stability in a dynamic ecosystem. Chemometry Meeting, Nijmegen, 24 November.
Van der Meer, J. & T. Piersma. Recent changes in the population size and spatial distribution of wintering Knots in

NW Europe in the period 1969-1994. Wader Study Group Conference, Aveiro, Portugal, 16 September.
Van der Meer, J. Interference and the spatial distribution of ideal and free predators. Workshop Modelling Geese Populations, Universtiy of Bristol, UK, 29 November.
Van der Meer, J. Fledging time of Alcidae and the abuse of dynamic programming. Workshop Dynamic Programming, University of Groningen, 2 December.
Van Duyl, F.C. Coral reefs of the Netherlands Antilles: research on endangered systems. Nederlandse Dierkundige Vereniging, NIOZ, 19 May.
Van Duyl, F.C. & A.J. Kop. Heterogeneity and short-term dynamics in bacterial production and biomass in North Sea sediments. Int. Workshop Aquatic Microbial Ecology, Konstanz, Germany, 21 April.
Van Haren, J.J.M. ADCP: Acoustic remote sensing of water flow. Nederlandse Oceanografen Club, Utrecht, 15 March.
Van Heemst, J.D.H., S. Peulvé, J.W. De Leeuw, M.-A. Sicre & A. Saliot. Algal polyphenolic resistant macromolecules in marine dissolved and particulate organic matter. 17th International Meeting on Organic Geochemistry, San Sebastian, Spain, 4-8 September.
Van Heemst, J.D.H., S. Peulvé, J.W. De Leeuw, M.-A. Sicre & A. Saliot. Algal derived polyphenols as resistant fraction of DOM and POM. Verwey Symposium, NIOZ, 30 January-1 February.
Van Iperen, J.M. Diatoms from the Arabian Sea upwelling areas (Somalia, Yemen): a comparison of assemblages and fluxes in sediment traps and surface sediments. Nederlands-Vlaamse Kring van Diatomisten, RGD, Haarlem, 21 April.
Van Raaphorst, W. Mineralization and early diagenesis in the sediments of the North Sea along the transport route of particulate suspended matter. NIOO-CEMO, Yerseke, 12 January.
Van Raaphorst, W. & P. Ruardij. Benthic nutrient regeneration in the ERSEM ecosystem model for the North Sea. Course Graduate School of Functional Ecology, NIOZ, 6 April.
Van Raaphorst, W., C.J.M. Philippart & J.C. Smit. Spatial and temporal variability of SPM in the North Sea. NOWESP annual meeting, Leuven, Belgium, 20 June.
Van Raaphorst, W. Early diagenesis of carbon an nutrients in shelf seas. Hogeschool Midden Nederland, NIOZ, 9 May.
Van Weering, Tj.C.E. Recent sedimentation in shelf seas: the Skagerrak and Norwegian Channel. Invited Lecture Max Planck Institute Bremen, 5-6 April.
Van Weering, Tj.C.E. Recent shelf sea sediments and shelf/slope exchange processes. Invited lecture EC Research Conference on Regional Seas, Granada, 22-26 April.
Van Weering, Tj.C.E., S. Van den Brenk & G.J.A. Brummer. Sediment dynamics of the Somali Basin continental margin, NW Indian Ocean. Arabian Sea Workshop, NIOZ, 13-16 February.
Van Weering, Tj.C.E. OMEX Benthic Boundary Layer Dynamics. 2nd Workshop EU Exchange Processes at the Continent/Ocean Margins in the North Atlantic, Knokke, 22-24 February.
Van Weering, Tj.C.E. & T. Nielsen. Development of Norwegian Sea Deep Water flow; seismic evidence from the Faeroe margin. Göteborg, 1st Nordic Marine Sciences Meeting, 23-26 March.
Van Weering, Tj.C.E. & H. De Stigter. Recent sedimentation and benthic boundary layer dynamics at the NE Biscay margin. 2nd MAST days and Euromar Market, Sorrento, 7-11 November.
Van Weering, Tj.C.E. Cold seeps at plate boundaries. Workshop East Indonesian Plate Tectonic History, Free University Amsterdam, 18-19 December.
Veldhuis, M.J.W. Flow-cytometry, more than just counting cells? Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, Maine, US, 1 December.
Versteegh, G., R. Riegman, J.W. De Leeuw & J.H.F.Jansen. The U^{k}_{37} Palaeotemperature Proxy: An overview. GSC Atlantic, Geol. Survey of Canada, Dartmouth, Nova Scotia, 12 October.
Versteegh, G., R. Riegman, J.W. De Leeuw & J.H.F. Jansen. The influence of temperature and other environmental parameters on the U^{k}_{37} alkenone ratio. Université du Québec à Montréal, GEOTOP-UQAM, 17 October.
Versteegh, G. Cyclic environmental changes in the Mediterranean Pliocene - a palynological approach. University of Tasmania, Hobart, 20 November.
Vosjan, J.H. Lecture series on Marine Bacteriology for the International Postgraduate Training course on Fundamental and Applied Marine Ecology of the Free University Brussels, November.
Vosjan, J.H. Microbiological studies on the effect of UV-b in Antarctica. Van Hall Institute, Groningen, 25 April.
Vosjan, J.H. Antarctic microbiology. Van Hall Institute, Groningen, 7 December.
Walker, P.A. & H.J.L. Heessen. Long-term changes in ray populations in the North Sea. ICES Symposium Long-term Changes in the North Sea Ecosystem, Århus 1975 Revisited. Århus, Denmark, 11-15 July.
Walker, P.A. Elasmobranch fisheries in the Netherlands. ICES Study Group on Elasmobranch Fishes, Copenhagen, 15-18 August, and the inaugural meeting of the proposed European Elasmobranch Society, Brussels, 10-11 September.
Wiebinga, C.J. Bacterial production in the Arabian Sea. Arabian Sea Dynamics Symposium, Plymouth, 18-19 December.
Wiebinga, C.J. Abundance and productivity of heterotrophic bacterioplankton in relation to seasonal upwelling in the NW Indian Ocean. Arabian Sea Workshop, NIOZ, 13-16 February.

EXTERNAL PROFESSIONAL FUNCTIONS

M.A. Baars

- member Indian Ocean Committee (GOA)
- member JGOFS Indian Ocean Planning Group (SCOR)
- member Working Group JGOFS Nederland
- co-editor Journal of Sea Research
- member discussiegroep Zooplankton-FRIENDS (SLW)
- board member Stichting ter Bevordering van de Nederlandse Oceanografie

R.P.M. Bak
- professor Tropical Marine Biology, University of Amsterdam
- senior Editorial Advisor Marine Ecology Progress Series
- member Neth. SCOR Committee (KNAW)
- member SCOR Working Group 104 Coral Reefs
- member Coral Reef Committee International Association of Biological Oceanography
- member Board Foundation for Scientific Research Surinam and the Netherlands Antilles
- member Atlantic Reef Committee
- co-editor Journal of Sea Research

J.P. Beks
- member of standardization committee on the analysis of ^{210}Po and ^{210}Pb NNI

M.J.N. Bergman
- member Working Group on Ecosystem Effects of Fishing Activities ICES

J.J. Beukema
- editor-in-chief Netherlands Journal of Sea Research
- board member Working group Populatiebiologie SLW

J.P. Boon
- member Marine Chemistry Working Group of ICES
- member Working Group on the Effects of Pollutants of ICES
- member of the National Organizing Committee of the International Symposium Dioxin '96, to be held in Amsterdam August 1996
- member of the 'Commissie voor de Milieu-Effect Rapportage'. Advice to the government on an alternative location for the dumping of Rotterdam harbour dredge spoil

G.J.A. Brummer
- member 'SOZ gebruikers-adviesgroep Verankerde Systemen' (GOA)
- member NWO/GOA research program committee 'Tracing a seasonal upwelling'

G.C. Cadée
- member 'Commissie voor buitenlandse marien-biologische instituten KNAW'
- advisor Netherlands Journal of Aquatic Ecology
- associate editor Ichnos
- editor Netherlands Journal of Sea Research
- board member 'Nederlands Vlaamse Kring van Diatomisten'
- member Working group Antarctica IUCN

C.J. Camphuysen
- board member Netherlands Ornithologist' Union (NOU)
- chairman Dutch Seabird Group (NZG)
- editor Sula
- co-ordinator Dutch beached bird survey (NSO)
- secretary BEON working group 'Effecten van visserij op vogels en zeezoogdieren'
- member scientific steering group of the Symposium 'Seabird Distribution and Ecology in Relation to the Marine Environment' ICES/The Seabird Group, Glasgow 1996

R. Daan
- member Working group 'Monitoring rond Mijnbouwinstallaties'
- member 'Begeleidingsgroep Habitats' (BEON)

H.J.W. De Baar
- professor General Oceanography, University of Groningen
- interim chairman 'vakgroep mariene biologie', University of Groningen
- associate editor Marine Chemistry
- chairman committee Joint Global Ocean Flux Study (JGOFS)
- member NWO/NOP Programmeringsgroep Thema 1
- member MAB/SCOPE/IGBP committee KNAW
- member JGOFS working group Southern Ocean
- member steering committee Carbon Fluxes and Dynamic Processes in the Southern Ocean, symposium at Brest, August 1995.
- coordinator MERLIM research program (EU-MAST)

P. De Goeij
- general secretary International Wader Study Group

J.W. De Leeuw
- professor Organic Geochemistry University of Utrecht, fac. Earth Sciences
- member 'Koninklijke Nederlandse Academie van Wetenschappen' (KNAW)
- board member AWON-NWO
- board member LPP, University of Utrecht, Biology faculty
- board member Inst. für Chem. und Biologie des Meeres, Univ. Oldenburg

- board member EAOG (European Association Org. Geochem.)
- board member working group Mol. Mech. and Anal. Chem. NIOZ-TUD
- professor Geochemistry, Univ. Barcelona

P.A.W.J. De Wilde
- professor Marine Zoology, University of Groningen
- member 'Programma Commissie Open Universiteit', Heerlen
- member 'Curatorium Forschungszentrum Terramare,' Wilhelmshaven, Germany
- member Benthos Ecology Working Group, ICES
- member Biological Oceanography Committee, ICES
- board member 'Onderzoekschool Functionele Oecologie'
- member MER Working Group Proefboringen Noord- en Waddenzee

G.C.A. Duineveld
- member ICES Benthos Ecology Working Group

D. Eisma
- professor Marine Sedimentology, University of Utrecht
- member Scientific Council Laboratory for Sedimentology and Environmental Research in Lakes and Waste Waters, Nanjing, China
- member Working group on marine sediments in relation to pollution ICES
- member 'Projektgroep slibeigenschappen en coördinatiecommissie slib, Raad van Overleg fysisch oceanografisch onderzoek Noordzee'
- advisory professor East China Normal University, Shanghai
- member Aquatic and Atmospheric Physical Sciences Research Grants and Training Awards Committee (AAPS RG & TA) NERC
- member BRIDGE Steering Committee (NERC)
- member of research School Sedimentary Geology

J.M. Everaarts
- member Working Group on biological effects of contaminants ICES
- member Marine Environmental Quality Committee ICES
- member Editorial Board of the Bulletin of Environmental Contamination and Toxicology
- member Editorial Board Ecotoxicology
- member Editorial Board Wallaceana

M. Fonds
- member Mariculture Committee ICES

H.G. Fransz
- member 'Werkverband JGOFS-Nederland' (GOA)
- member 'GLOBEC werkgroep voor numerieke modellering' (NMWG)
- member ASMO-working group for International Model Comparison

F.C. Hansen
- member 'SLW-discussiegroep Zoöplankton-FRIENDS'

W. Helder
- member Dutch SCOR commission
- member Dutch LOICZ commission
- chairman 'Gebruikers Adviesgroep Auto-Analyser (GOA)'
- member steering committee ALIPOR (MAST III)
- special editor Netherlands Indian Ocean Programme volume of Deep Sea Research
- co-editor Journal of Sea Research
- associate editor Estuaries

J.H.F. Jansen
- member GEONETH, Geoscience Network of the Netherlands for International Cooperation
- member 'Nederlandse Ocean Drilling (ODP) Werkgroep'
- member Scientific Committee: Dynamique à long terme des écosystèmes forestiers intertropicaux. Symposium International, Paris, 20-21 March 1996.

W.C.M. Klein Breteler
- member 'SLW-discussiegroep Zoöplankton-FRIENDS'
- representative GLOBEC for the Netherlands
- member 'Nederlandse werkgroep deeltjes-karakterisering'
- member users group Quantimet (Image Analysis)

G.W. Kraay
- member flow-cytometer working group

H.J. Lindeboom
- member 'Commissie voor Milieueffectrapportage'
- member 'Kernbegeleidingsgroep ecologie Noordzee en Waddenzee'

- external examiner Hogeschool 'Noorderhaaks' environmental science
- member ICES werkgroep 'Effects of Fisheries'
- chairman 'Begeleidingsgroep Effekten Visserij' (BEON)
- chairman 'Werkgroep effekten visserij op vogels en zeezoogdieren' (BEON)
- coordinator EG-project IMPACT-II
- member Board of the Sir Allistair Hardy Foundation of Ocean Sciences

L.R.M. Maas
- (co-)convenor of EGS-session OA4, EGS-conference 6 April '95

W.G. Mook
- professor of Isotope-Physics, University of Groningen
- professor Application of Isotopes in Earth Sciences, Free University, Amsterdam
- member 'Koninklijke Nederlandse Academie van Wetenschappen' (KNAW)
- member Academia Europaea
- member 'Sectie Aardwetenschappen' (KNAW)
- member 'Academie Raad voor de Aardwetenschappen' (KNAW)
- member ICSU-committee
- member 'Klimaatcommissie/nationale WCRP-commissie' (KNAW)
- member INQUA-committeee/national PAGES-committee (KNAW)
- member IGBP/MAB/SCOPE committee (KNAW)
- member 'Wetenschappelijke Adviesraad Onderzoekschool Sedimentaire Geologie'
- member 'Vaste Adviescommissie Zeegaand Onderzoek (VAZ) van NWO/BOA'
- board member International Research School Fundamental and Applied Nuclear and Atomic Physics (FANTOM)
- chairman/nominated member SCOR Nederland (KNAW)
- member Committee 'Watersysteem Verkenningen'
- member 'Raad van Overleg van het fysische oceanografisch onderzoek van de Noordzee'
- member PACT-committee Raad van Europa

M. Mulder
- member Working group 'Monitoring rond Mijnbouwinstallaties'

R.F. Nolting
- member EC commission certification of sea- and estuarine water for trace metals
- member 'Gebruikersgroep CTD-systemen' (SOZ)

S. Ober
- chairman 'Gebruikers-adviesgroep CTD-systemen' (SOZ)

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- board member Nederlandse Vereniging voor Aquatische Ecologie

T. Piersma
- vice-chairperson of the International Wader Study Group (WSG)
- member editorial board Ardea
- member editorial board Current Ornithology
- member of Science Committee of Estuaries Unit of the British Trust for Ornithology
- member BirdLife International/IWRB Grebe Specialist Group

H. Ridderinkhof
- member 'Overleggroep Waterstanden en Getijden van de Raad van Overleg voor het Fysisch Oceanografisch onderzoek van de Noordzee'
- member 'Overleggroep Stoftransporten van de Raad van Overleg voor het Fysisch Oceanografisch onderzoek'

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- secretary SLW Working group 'Aquatische Oecologie'
- co-editor Journal of Sea Research

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- member 'Directeuren Overleg Beleidsgericht Ecologisch Onderzoek Noordzee/Waddenzee' (BEON)

J.S. Sinninghe Damsté
- associate scientist University of Utrecht, faculty of Earth Sciences
- associate editor Organic Geochemistry

D.H. Spaargaren
- secretary 'Commissie voor Buitenlandse Marien Biologische instituten', KNAW
- member Board of Advisory Editors of CRUSTACEANA, international journal of crustacean research
- member Council of European Working Group on Chemical Evolution, Early Biological Evolution and Exobiology
- member Society for Experimental Biology
- member Groupement pour l'Avancement de la Biochemie Marine, Gif/Yvette

- secretary / treasurer Organ. committee IVth International Crustacea Congress, Amsterdam, July 1998

C.C. Ten Hallers-Tjabbes
- adviser to IUCN for the London Convention 1972

E. Van Abs
- member Committee 'Zeegaand onderzoek Stichting Onderzoek der Zee' (SOZ)
- member 'Overlegorgaan Faciliteiten Zeeonderzoek' (OFZ)

H.M. Van Aken
- chairman Nederlandse Oceanografen Club
- member of the WOCE Hydrographic Program Planning Committee
- member of the ICES Hydrography Comittee
- member of the ICES Working Group on Ocean Hydrography
- member Arctic Oceans Sciences Board

M.A. Van Arkel
- member Working group 'Monitoring rond Mijnbouwinstallaties'

A.J. Van Bennekom
- deputy member Antarctica-committee SOZ
- co-editor Circumpolar Journal
- member ARA (Akademie Raad voor de Aardwetenschappen), KNAW
- member ICES Working Group on Oceanic Hydrography

S.J. Van der Gaast
- editorial board Applied Clay Science

J. Van der Meer
- member Working Group on the statistical aspects of environmental monitoring (ICES)

H.W. Van der Veer
- special editor Proceedings Second International Symposium on Flatfish Ecology, Texel 1993
- member Organizing Committee 6th International Conference of Coelenterate Biology, Noordwijk 1995
- member Organizing Committee Third International Symposium on Flatfish Ecology, Texel 1996
- member Working Group on Recruitment Processes ICES
- adjunct associate-professor of Zoology, North Carolina State University, Raleigh USA
- adjunct associate-professor of Marine Science, University of South Carolina, Columbia USA

F.C. Van Duyl
- board member Treub-Mij
- advisor Studiekring Suriname en de Nederlandse Antillen

W. Van Raaphorst
- member Steering committee NOWESP (ECMAST II)
- member 'Begeleidingsgroep Eutrofiëring' (BEON)

Tj.C.E. Van Weering
- member steering Committee ESF Network on Mediterranean Geosciences
- member Steering Committee OMEX (Mast II)
- member Steering Committee ENAM (Mast II and III)
- member Editorial Board Geologie en Mijnbouw
- member Editorial Board Marine Geology
- special Editor Indian Ocean Volume of Journal Deep Sea Research
- special Editor Proceedings Third Conference Gas in Marine Sediments

M.J.W. Veldhuis
- project leader NWO/NOP 'Platform Verstoring van Aardsystemen no. 9 '(NIOZ)
- member JGOFS North Atlantic Planning Group
- adjunct professor University of New England

C. Veth
- member Southern Ocean Planning Group for JGOFS
- member Committee Antarctic Research
- member 'Overleggroep waterstanden en getijden' van de Raad van Overleg voor het Fysische Oceanografisch onderzoek van de Noordzee
- membre du Comité Scientifique de JGOFS France
- member Working group Joint Ocean Global Flux Study NWO/GOA
- advisory member 'School voor Atmosferisch en Marien Onderzoek'

J.H. Vosjan
- lecturer Marine Bacteriology, Free University Brussels, Belgium
- member committee 'Risico's UV straling Gezondheidsraad'

M.R. Wernand
- member Optics task Team JGOFS
- member Sea WiFS Scientific Team
- member MERIS Calibration/Validation Committee ESA

J.T.F. Zimmerman
- professor Physical Oceanography, Rijksuniversiteit Utrecht
- editor Netherlands Journal of Sea Research
- member editorial board Continental Shelf Research
- IAPSO representative national UGGI comité (ARA-KNAW)
- member Sub-committee Marine Geodesy RCG
- member Committee 'Milieueffectrapportage'
- member Neth. Committee Geodesy (ARA-KNAW)
- member 'Themacommissie Kustonderzoek' van BOA-NWO
- member New York Academy of Sciences
- member of peer review committee of Proudman Oceanographic Laboratory, Bidston, UK

MEETINGS, COURSES AND COLLOQUIA HELD AT NIOZ

Meetings, *etc.*

Verwey Symposium. From 30 January to 1 February the seventh annual Verwey Symposium was held at NIOZ. These symposia are part of the national Ph.D. programme in Marine Life Sciences organized by the University of Groningen and the Netherlands Institute for Sea Research, and are integrated in the educational programme of the Graduate School of Functional Ecology.

Arabian Sea Workshop. This workshop, organized by Dr. M.A. Baars and financed by the Netherlands Geosciences Foundation (GOA), was held from 14 to 16 February. Some 90 scientists, from 12 nations, discussed data collected in the NW Indian Ocean during the Netherlands Indian Ocean Programme 1992-1993 by RV 'Tyro'.

Changes in PCB patterns in fish-eating mammals, a workshop organized by J.P. Boon was held from 18 to 20 February. Participants came from UK, Norway, Denmark and the Netherlands.

MFO Symposium. On 17 and 18 May presentations were given by Ph.D. students Meteorology and Physical Oceanography of NIOZ and several Dutch universities.

National Workshop Biological Effect Monitoring, organized by C. Van Zwol and J.P. Boon, was held from 11 to 12 September with participants from the National Institute for Coastal and Marine Management and NIOZ.

NOWESP workshop: This workshop on long-term time series of physical parameters, suspended particulate matter, phytoplankton, primary production and zooplankton at 8 stations on the north-west European shelf, organized by W. Van Raaphorst, R.W.P.M. Laane (RIKZ) and F.C. Colijn (University of Kiel), was held from 30 October to 1 November. The 17 participants from Germany, Belgium, Norway, the UK and The Netherlands discussed the joint analysis of the data sets.

The 7th International Plant Taphonomy meeting held from 10 to 12 November was organized by G.C. Cadée and J.W. De Leeuw, with participation by 30 German, Austrian, British and Dutch scientists.

Course ICES/DiS: From 16 to 18 October a course was held for a group of 34 American/Canadian/Danish marine biology students studying in Copenhagen under the auspices of DiS (Denmark's International Study Program) and ICES. The course comprised lectures by NIOZ scientists, introduction to ongoing NIOZ research projects, laboratory work and work at sea.

NIOZ Courses

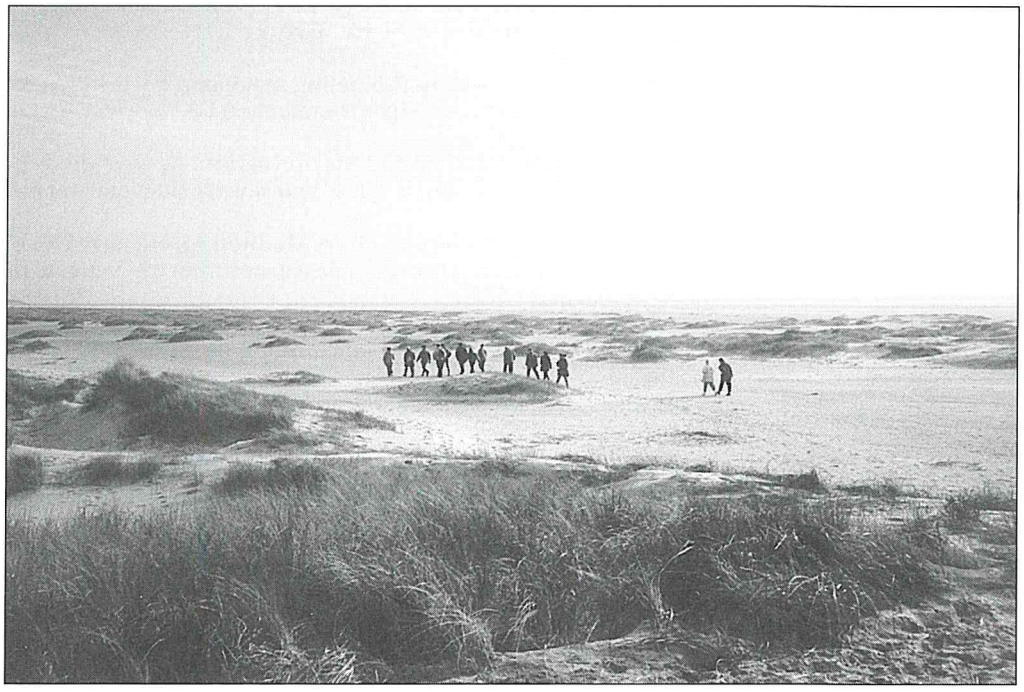
The course **Introduction to Oceanography** is part of the Marine Biology curriculum at the University of Groningen and was attended by 66 students, 28 majoring marine biology and 38 majoring environmental biology. The introductory lectures were given at Groningen from 6 to 14 February by Prof. Dr. H.J.W. De Baar. The 38 environmental biologists took part in a one-day excursion with demonstrations at NIOZ on 15 February. The 29 marine biologists followed a set of several practical projects in the weeks of 20 through 31 March, including field work at the tidal flats and aboard the vessels 'Navicula' and 'Pelagia' in waters of the Wadden Sea and the North Sea. Each marine biology student completed a written report on one of the research projects. The enthusiastic commitment of a great number of NIOZ scientific and support staff ensured an over-

all very stimulating practical course. The students evaluated the course as overall very interesting and useful. The final examination was taken by 23 marine biology students, of which 20 passed, and 33 environmental biology students, of which 29 passed.

The course **Marine Ecosystems**, which is part of the Marine Biology programme of the University of Groningen, was held from 5 to 30 June. There were 22 participants.
The course started on 5 June at the Biological Centre, Haren, with introductory lectures by Prof. Dr. P.A.W.J. De Wilde. The practical part was held at NIOZ from 12 to 23 June and comprised two overnight sampling trips with RV 'Pelagia' to the North Sea (Frisian Front and Oyster Grounds), fishing and sampling benthos in the Wadden Sea with RV 'Navicula', and experimental work. The latter involved the study of factors that limit phytoplankton growth, light inhibition, and micro-zooplankton grazing experiments. As usual, the students together produced a book of 'course results'. The last week of the course was spent studying literature and writing individual reports, ending with the final examination on 30 June.

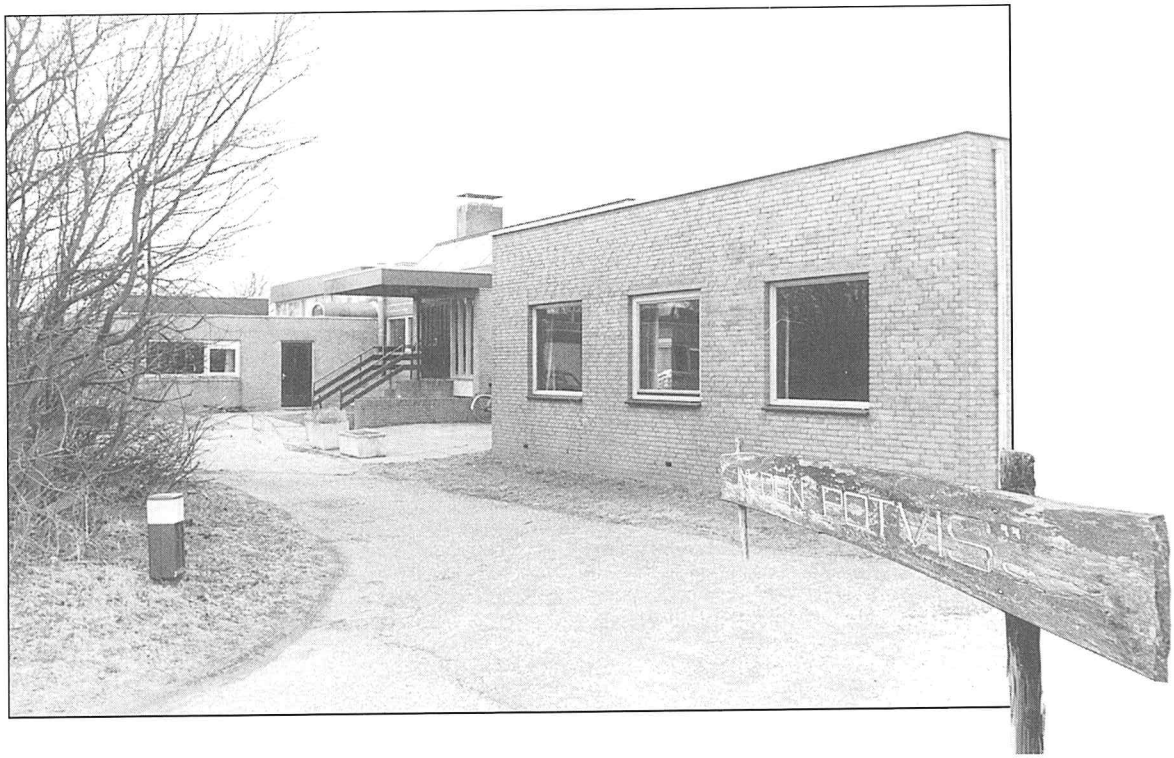
A **Marine ecological modelling course** for Ph.D. students of the Graduate School of Functional Ecology was organized by Dr. H.G. Fransz from 3 to 7 April. There were 12 participants from the Netherlands and 1 from Germany.

The course **Introduction to Marine Sciences**: The second part of this course for Ph.D. students, which started in 1994, was held at NIOZ from 20 to 24 November. Sixteen Ph.D. students participated in the course, which is a co-operation between NIOZ and the Graduate Schools. The books used are those of the English Open University. Topics treated were the physics of waves and tides, the geology of sediments, the chemistry of bottom processes and the biology of benthic systems and macrofauna.



Attendents of the 7th Internationale Plant Taphonomy workshop on Texel.
Photo: G. Eglinton.

3. Guest scientists, visitors and students



GUEST SCIENTISTS

- Ben Khelifa, Dr. L., Laboratoire d'Hydrologie et de Géochimie isotopique, Université Paris-Sud, Orsay, France: Department of Marine Chemistry and Geology, 1 January - 30 April.
- Billones, R.G., Free University, Brussels: Department of Biological Oceanography, 8-10 February.
- Carlotti, Dr. F., CNRS Station Zoologique, Villefranche-sur-Mer, France: Department of Biological Oceanography, 4-15 July.
- Checa, Prof. Dr. A., Dep. Estratigrafia y Paleontologia. Univ. Granada, Spain: Department of Marine Ecology, 19 July-1 August.
- Conan, S.M.H., Centrum voor Mariene Aardwetenschappen, Free University, Amsterdam: Department of Marine Chemistry and Geology, January.
- Davidson, Dr. N.C., Joint Nature Conservation Committee, Peterborough, UK: Department of Marine Ecology, 10-20 April.
- Gordon, Dr. Ch., Volta Basin Research Project, University of Ghana, Accra, Ghana: Department of Marine Ecology, 10 June - 20 July.
- Gudmundsson, Dr. G.A., Icelandic Museum of Natural History, Reykjavik, Iceland: Department of Marine Ecology, 20-30 March.
- Hu Jiamin, Dr., Shanghai East China Normal University, China: Department of Marine Chemistry and Geology, 2 - 24 July.
- Li Bogen, Dr., Hangzhou Second Institute of Oceanography, China: Department of Marine Chemistry and Geology, 22 September 1995 - 2 February 1996.
- Lu Jian Jian, Dr., Shanghai East China Normal University, China: Department of Marine Ecology, 1 January - 1 May.
- Mao Zhichang, Dr., Shanghai East China Normal University, China: Department of Marine Chemistry and Geology, 20 July 1995 - 2 February 1996.
- Ntiamoa-Baidu, Prof. Dr. Yaa, Department of Zoology, University of Ghana, Accra, Ghana: Department of Marine Ecology, 10 June - 20 July.
- Power, J.H., Coastal Fisheries Institute, Louisiana State University, USA: Department of Marine Ecology, 20 March-28 April.
- Ruiz, Dr. G.M., Smithsonian Environmental Research Centre, Edgewater, USA: Department of Marine Ecology, 23-28 September.
- Sarkar, A., National Institute of Oceanography, Dona Paula, Goa, India: Department of Biogeochemistry and Toxicology, 27 February-26 May.
- Schoumann, V., Université Libre de Bruxelles: Department of Marine Chemistry and Geology, 1 January - 31 December.
- Smith, Dr. D., Northeastern University, Boston, USA: Department of Marine Ecology, 23-28 September.
- Stokes, A., Coastal Fisheries Institute, Louisiana State University, USA: Department of Marine Ecology, 21 April - 28 May.
- Walton, W.C., Smithsonian Environmental Research Centre, Edgewater, USA: Department of Marine Ecology, 23-28 September.
- Zdanowski, Dr. M.K., Department of Antarctic Biology, Polish Academy of Sciences, Warsaw, Poland: Department of Biological Oceanography, 6-20 May and Oktober-November.

VISITORS

- Albers, Dr. B., Terramare, Wilhelmshaven FRG.
- Benner, Dr. R., Marine Science Institute, The University of Texas at Austin, Port Aransas, USA.
- Bird, Dr. M., Research School of Earth Sciences, Australian National University, Canberra, Australia.
- Biscaye, P.E., Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA.
- Boyd, Dr. H., Canadian Wildlife Service, Ottawa, Canada.
- Briggs, Dr. D.E.G., Department of Geology, University of Bristol, Bristol, England.
- Chen Jiyu, Prof., ECNU, Shanghai, China.
- Cheng, Dr. L., Scripps Institution of Oceanography, La Jolla, USA.
- Clark, Prof. Dr. C., Department of Applied Mathematics, University of British Columbia, Vancouver, Canada.
- Collinson, Dr. M.E., Organic Geochemistry Unit, University of Bristol, Bristol, England.
- Droz, Dr. L., IFREMER, Centre de Brest, Plouzané, France.
- Eglinton, Dr. T.I., Department of Chemistry, Woods Hole Oceanographic Institution, Woods Hole, USA.
- Eglinton, Prof. G., Organic Geochemistry Unit, University of Bristol, Bristol, England.
- Elnabawi, Dr. A., Department of Toxicology, University of Kiel, FRG.
- Fedorak P.M., Department of Microbiology, University of Alberta, Edmonton, Alberta, Canada.
- Friedrichs, C.T., Virginia Institute of Marine Sciences, Gloucester Point, USA.
- Frost, R.L. Centre for Instrumental and Developmental Chemistry, School of Chemistry, Queensland University of Technology, Brisbane, Queensland, Australia.
- Gehlen, Dr. M., Centre des faibles Radioactives, CNRS-CEA, Gif sur Yvette, France.
- González, Patricia M., Direccion de Fauna, Provincia de Rio Negro, San Antonio Oeste, Argentina.
- Hartgers, Dr. W.A., Departamento de Quimica Ambiental, Centro de Investigación y Desarrollo, Barcelona, Spain.
- Henderson, Dr. P.A., University of Oxford, UK.
- Hoppema, Dr. M., AWI, Bremerhaven, FRG.
- Johannessen, Dr. T., Flødevigen Marine Research Station, His, Norway.
- Kannan, Dr. N., Department of Marine Chemistry, Institute of Marine Sciences, University of Kiel, FRG.

- Karlson, Prof. Dr. R., Ecology Program, Univ. of Delaware, Newark, Delaware, USA.
- Kenig, Dr. F., Department of Geology and Geophysics, University of Hawaii, Honolulu, USA.
- Lindström, Dr. Å., Department of Animal Ecology, Lund University, Sweden.
- Navarro, Dr. R.A., Avian Demography Unit, University of Cape Town, South Africa.
- Nellen, Prof. Dr. W., University of Hamburg, Germany.
- Rigaut, F., IFREMER, Centre de Brest, Plouzané, France.
- Ruiz, Dr. G.M., Smithsonian Environmental Research Center, USA.
- Schneider, Dr. R.R., Fachbereich Geowissenschaften, Universität Bremen, FRG.
- Seaby, Dr. R.M.H., Fawley Aquatic Research Laboratories Ltd, Hampshire, UK.
- Smayda, Prof. Dr. T., Graduate School of Oceanography, University of Rhode Island, Kingston R.I., USA.
- Smith, Prof.S.L., Rosenstiel School of Marine and Atmospheric Sciences, Miami, USA.
- Tintelnot, Dr. M., Forschungsinstitut Senckenberg, Wilhelmshaven, FRG.
- Van Aarssen, Dr. B.G.K., School of Applied Chemistry, Curtin University of Technology, Australia.
- Van Bergen, Dr. P.F., Organic Geochemistry Unit, University of Bristol, Bristol, England.
- Venkatraman, P., Department of Marine Chemistry, Institute of Marine Sciences, University of Kiel, FRG.
- Volkman, Dr. J.K., CSIRO, Division of Oceanography, Marine Laboratories, Hobart, Australia.
- Von Rad, Dr. U., Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, FRG.
- Wang Xuan, Research School of Earth Sciences, Australian National University, Canberra, Australia.

UNDERGRADUATE UNIVERSITY STUDENTS

- Bies, B., Department of Marine Biology, RUG.
- Bosch, H.J., Institute of Earth Sciences, Department of Geology, RUU.
- Brookes, R., University of Hertfordshire, Hatfield, UK.
- De Boer, M., Biol. Oceanography, RUU.
- De Koning, H.W., Department of Geology, Institute of Earth Sciences, RUU.
- De Senerpont-Domis, L., Biol. Oceanography, RUU.
- Fischer, A., University Zürich, Switzerland.
- Hartog, W., Institute of Earth Sciences, RUU.
- Helle, M., Department of Marine Biology, RUG.
- Jonkers, P.J., Department of Marine Biology, RUG.
- Kloff, S., Department of Marine Biology, RUG.
- Langevoord, M., ISP, UvA.
- Luttikhuizen, P., Department of Marine Biology, LUW.
- Santos, S., Free University Brussels.
- Scheffers, S., Biol. Oceanography, UvA.
- Stam, M., Biol. Oceanography, UvA.
- Steinhoff, W., ISP, UvA.
- Tuinstra, W., Dept. of Informatics, LUW.
- Van Damme, C., Department of Marine Biology, RUG.
- Van der Brugge, J., Department of Marine Biology, RUG.
- Van der Geest, H., ISP, UvA.
- Van der Heyden, A., Biol. Oceanography, LUW.
- Van Gils, J., Zoological Laboratory, Behavioural Biology, RUG.
- Veefkind, R., Institute of Earth Sciences, Gepartment of Geology, RUU.
- Wiegman, S., ISP, UvA.
- Wieringa, E., Department of Marine Biology, RUG.
- Zondervan, I., Department of Marine Biology, RUG.

4. Support Services

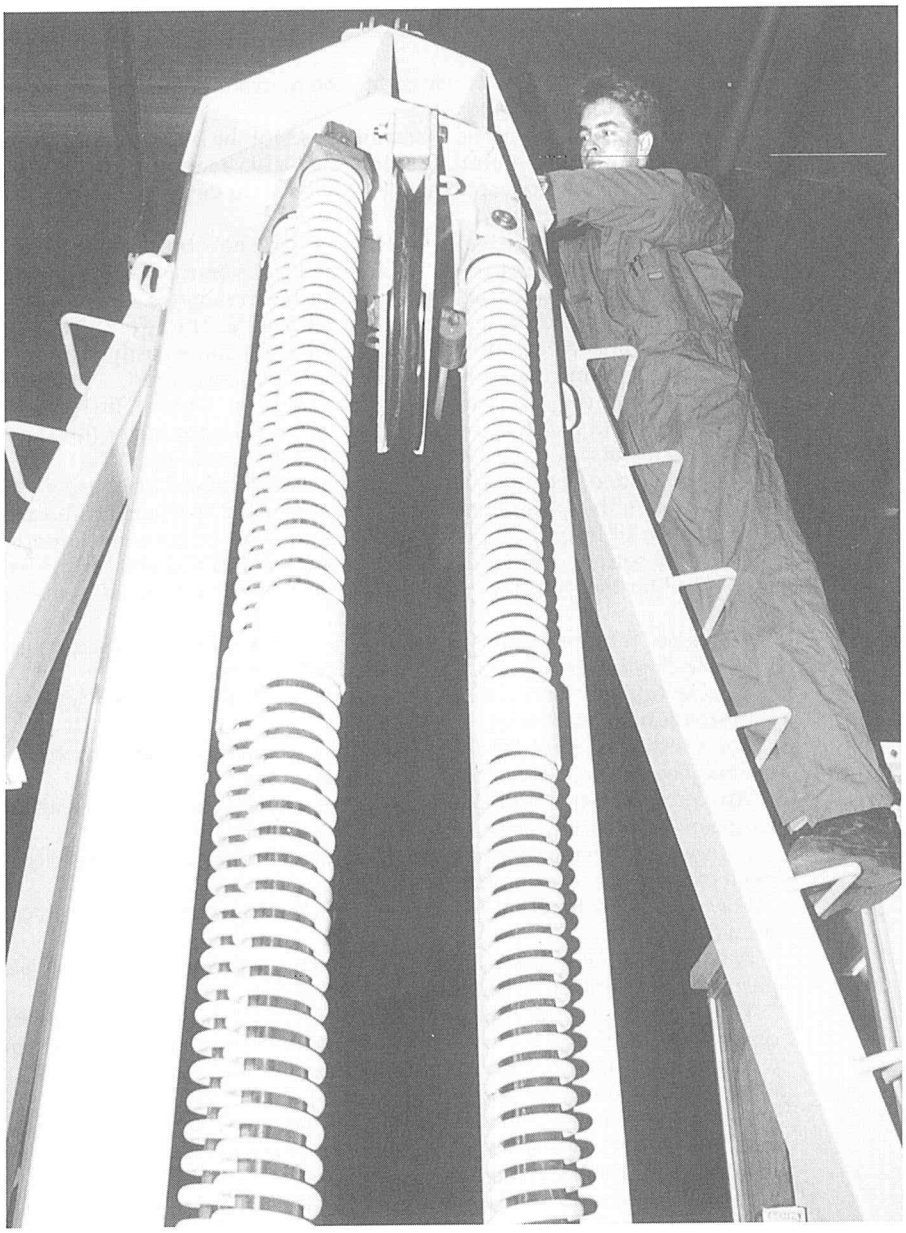


Photo: B. Aggenbach.

TECHNICAL SUPPORT

As required by law, a risk inventory has been carried out in the Technical Support Services. In the next few years various measures are to be implemented.

NIOZ has applied for a dredge and dumping permit up to 1998 for dredging operations in the NIOZ harbour.

The procedure to obtain an environmental permit is still running. An investigation has been carried out as to the sound levels around the institute.

A fixed hydraulic crane has been exchanged for the mobile crane of the IBN. The fixed crane has been installed on the IBN pier in the NIOZ harbour. NIOZ has taken over responsibility for the mobile crane. This has greatly increased the flexibility and hoisting capacity of both NIOZ and IBN.

A number of redundant plywood laboratory containers have been sold.

Instruments

Support and development

All the Technical Services have worked on maintenance, upgrading and further automation of the various instruments and systems developed in previous years, such as the core scanner, the bottom lander TROL and alkalinity meters.

A winch platform and a small Rosette sampler have been built for participants in cruises on board RV 'Polarstern'.

For the national Triple-B cruise eight current meter moorings have been made and deployed by RV 'Pelagia' in the Bay of Biscay.

A new thermistor string has been developed for the Department of Physical Oceanography. The string contains 32 temperature sensors which give a fast response and have a very high stability. With the present battery capacity of 30 Ah, the data logger of the thermistor string has a capacity of about 160 000 recordings.

A 30-year-old boxcorer has been replaced. The new boxcorer is the first to be provided with a delay mechanism developed by NIOZ technicians on the basis of video recordings during sampling. This is expected to cause less disturbance to samples.

A number of lab containers have been renovated. The seismic container has been refurbished and adapted in such a way that third parties may more easily connect their equipment. Also, a dual-channel seismic monitor amplifier has been constructed.

As agreed during the European Workshop on Optical Instruments and Remote Sensing (WOIRS '93, held at NIOZ), a prototype 6-channel light meter (low cost 6CRS) has been developed. Test results are expected to be available at the end of 1995.

A simple video system in underwater housing has been built using a standard Hi-8 video camera together with a programmable timer constructed specially for this purpose. This construction is to find multiple application in the new generation of bottom landers soon to be built.

A special battery charger has been developed for NiCd and MiMH batteries. It is to be further developed for the charging of batteries such as those to be used in the new generation of bottom landers.

To replace the energy-consuming magnetic valves of the hydraulic system of an oxygen filter a multiple-channel engine-operated valve has been developed.

The electronic system of a new type of oxygen titrator has been developed based on dual-colour transmission measurement.

For a sediment recorder a new electronic operation system has been developed and an electro-magnetic current meter built and implemented.

An electrically driven pivot plate with two current meters which can be fixed at different angles has been built for automatic calibration of internal compasses.

A servo-pneumatic robot for an automatic extractor is being developed for use in the Department of Biogeochemistry and Toxicology.

For an X-ray diffraction instrument (XRD) a high-temperature precision heat regulation has been developed.

A number of measuring devices have been made for the CO_2 analysis instruments of the Department of Chemical Oceanography and Geology.

To be able to produce independently functioning measuring equipment cheaply, a new development scope around the Texas Instruments micro-controller has been purchased.

A 'pick and place' system has been acquired for the production of SMT (Surface Mounted Technology). This allows the production of small-scale electronics.

A second-hand cant and milling machine has been acquired. A welding manipulator developed and built by NIOZ technicians for pistoncore pipes has come into operation, allowing rapid welding of the connectors to the pipes.

Much time was spent on the design, specification and offers for the 'Experimental Shorebird Facility'. Because of high costs, the construction of the aviaries will, if possible, be realized in three phases.

On board support and logistics

Besides the time required for the preparation of expeditions, NIOZ technicians spent about 100 man weeks of on board assistance during various cruises. Because HrMs 'Tydeman' is leaving in early 1996, preparations have already been carried out for a cruise to be undertaken with this ship in the Atlantic in July-September 1996.

For sea-going expeditions and various research programmes, transport was arranged to Argentina, Australia, Sri Lanka, Indonesia, the Seychelles, Crete, France, Italy, Germany, and in the Netherlands.

As now required by law, all dinghies have been insured and provided with a registration number.

The insurance of the ships has now been placed with another insurance company, which saves a considerable amount of money.

Various kinds of lost equipment had to be claimed with the insurance company, such as a CTD, an underwater camera, camera-equipped fishing gear, and a 20' container lost in the NIOZ harbour during a heavy storm.

Research vessels

RV 'Pelagia' has undergone complete maintenance above water. Also the installations have received preventive maintenance, and the certificates required have been renewed.

A 'Shipboard Oil Pollution and Emergency Plan' (SOPEP) drawn up by an external bureau has been approved by 'de Nederlandse Scheepvaart Inspectie' for use on board.

A mobile foundation for a traction winch was constructed and installed by NIOZ technicians for collection of deep-sea samples during the OMEX cruise. Due to the location of the weight (*ca* 15 tons) of the winch high on the C deck, stability calculations and ballast prescriptions have been adjusted by the shipbuilder Verolme Heusden.

A 3.5 Kc echo-sounder has been installed on board, and one of the blisters has been enlarged to house the 12 transducers of the echo-sounder. To register digital depth values of the echo-sounder on the ABC on board computer, a new digital interface for the depth digitizer has been developed. The next step will be to replace the analogous electronics.

To facilitate the generation of track-plots, which are used for position finding with the ABC on board computer system, a new and far more user-friendly digital interface is being developed.

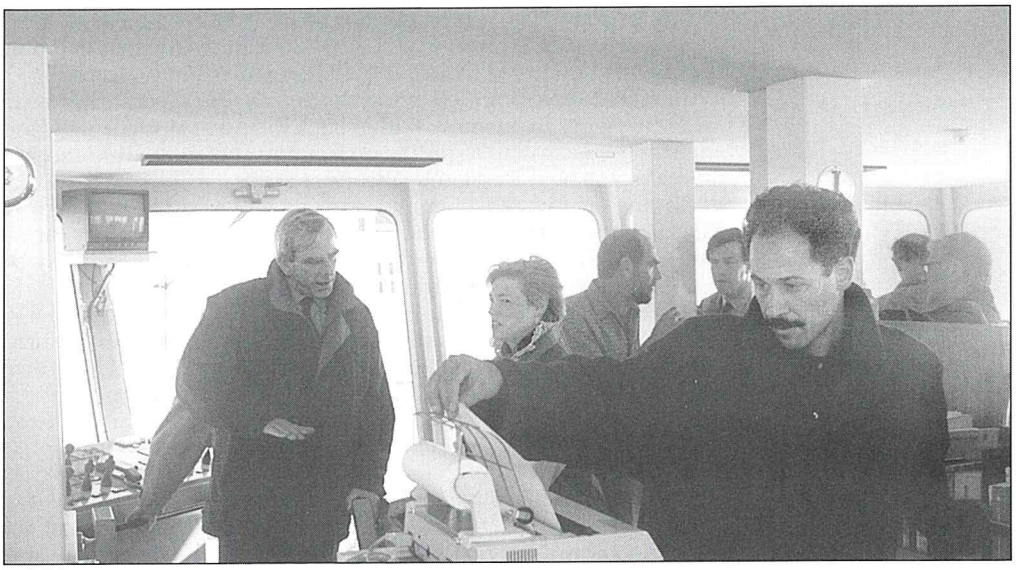
A 3-cm radar has been replaced with a 10-cm radar, to improve navigation during heavy rain and snow storms.

The CTD-winch has been given a new wire drum with a conductor cable of over 8000 m length to facilitate work in the deep sea.

For the 27-ton Towed Ocean Bottom Instrument (TOBI) of the NERC Institute of Oceanographic Sciences Deacon Laboratory, NIOZ technicians designed and constructed a counter foundation which was placed on the afterdeck for use during the ENAM cruise. After the cruise the foundation was sold to NERC. For the use of equipment that requires a large electric potential, such as the TOBI winch, an extra-heavy power supply has been placed on the afterdeck.

To ensure and improve the continuous registration of seawater data via the aqua-flow system the system has been moved from the forward deck to the emergency engine room in the midship.

The ship made 185 sailing days, including 18 weekends.



On 29 September, the Parliamentary Committee for Education and Science visited NWO. The visit took place on board the NIOZ RV 'Pelagia', which had sailed to Scheveningen for the occasion. During the afternoon a cruise was performed on the North Sea to demonstrate some of the main aspects of sea research.
Photo: NWO

Of RV 'Navicula' the BB propulsion engine has been overhauled and its hydraulic clutch renewed.

The 3-cm radar from RV 'Pelagia' has replaced the outdated system of RV 'Navicula'.

During dry-docking the underwater hull was steel-blasted and painted. A number of hull plates have been replaced. A bilge alarm has been installed under the accommodation floor.

The ship made 134 sailing days this year, including 5 weekends, with a total of 514 scientists participating.

RV 'Griend' was lifted out of the water with a crane and its under- and above-water body steel-blasted and painted.

The ship made 96 sailing days, mainly on the Wadden Sea.

Fish traps: As over the last 36 years, the fish traps at the Stuifdijk have been emptied every day between April and November. The catch was measured and counted. In contrast with former years, the catch has also been registered during the weekends to increase the number of data. A striking difference with previous years was the low catches in autumn, and the large number of the lesser weever caught during summer, a phenomenon also reported from the beaches along the Dutch coast.

Four trawl nets of small mesh size have been constructed for flatfish research.

Buildings and installations

Besides the general repair maintenance, a great deal of replacement was carried out this year thanks to a special NWO subsidy.

The dormitory of the Potvis was given a new roof, 80 windows were replaced and a ventilation system installed. The sanitary facilities were tiled and the underground pipeline of the central heating was renewed.

The plumbing of the roof of the main building was replaced together with the condensers of the cooling/freezing unit of the roof. About 800 roof trimjoints were renewed. The exterior lighting was renewed and energy-saving lightbulbs installed.

A large door in the fishing-net storage was replaced by a wall with a sliding door.

As part of the environmental regulations liquid-proof floors have been installed in the outdoor storage for chemicals. Drawings have been revised showing the places of all fixed instruments in the laboratories.

FINANCE AND ACCOUNTING

The past year was again a year full of disturbance for the Finance and Accounting Service (FED). First there was the general reorganization of the various departments that needed a lot of attention. The control function was introduced into the organization which changed the task and name of the FED into Finance and Control (FC). Although the new organizational structure came into force on 1 July, it was decided not to rearrange the corresponding budgets for the 1995 budget year. The workload that would have been created for the FC by providing the new departments with new budgets for a 4-month period, together with the ongoing work on the introduction of the new financial software EXACT, would have meant too much strain.

The new software will be put into effect as from 1 January 1996. This software will facilitate the separation of the normal financial bookkeeping of the Institute from the administration of the scientific and support activities of NIOZ, organized in projects.

In order to describe these projects properly, the scientific departments will have to describe their scientific work in 'themes'. Within such themes, priorities will have to be set and developed into defined projects with a specific programme, time-schedule and budget. In such budgets, internal services will be calculated by means of tariffs.

To prepare the 1996 budget, a division will be made between 'infrastructural' costs (overhead) and financial means for projects, including enough reserves for new projects. This will facilitate the calculation of tariffs for internal and external use (sponsors). Moreover, the administration of the Marine Research Facilities (NIOZ-F) will be done separately.

In the course of the year Eric Huffnagel joined the FC as interim manager Finance & Control. His task has been to reorganize the financial administration in such a way that adequate measures can be taken to solve the overspending of budgets. Part of his work has also been the modification of the staffing of the department. Chris Luursema's contract was not renewed, while Dick Bruin left the department at the end of the year, anticipating his VUT-retirement in March 1996. A new head of the Financial Administration has been appointed and procedures have started to select a new Finance and Control manager.

In the new year, all administrative activities - including inventory control and the supply service - will be linked to the new EXACT software. Depreciation of material investments will start in order to allow consolidation of the NIOZ balance and annual account with that of the NWO-organization.

SCIENTIFIC SUPPORT

Centre for Information Processing and Automation (CIA)

This year was characterized by two events: 1. the prolonged absence due to ill health of one of the employees; this problem was solved by temporarily placing one of the employees of the Electronics Services in our Department; and 2. the announcement that NWO is willing to give a financial injection for a structural improvement of the computer infrastructure of the Institute. For the preparation, execution and implementation of the planned modernization and upgrading of the computer network, a project group called Impulse has been set up. The plan has been examined by the 'Wetenschappelijk/Technische Raad' (WTR) of SURF, who has reported positively to NWO. NIOZ appreciates the suggestions made by the 'Wetenschappelijk/Technische Raad' and will be glad to incorporate them in the implementation of the plan.

The reorganization of the Institute has also affected CIA. Of its three staff members, two have been allocated to a scientific department and one has been placed in the Electronics Service.

The periodical 'Octopus' has been continued and now appears on the WWW pages. Also other relevant news can be found there.

Technical Committee and User Committee

The Technical Committee discussed the technical aspects of automation problems and gave advice to the director. Committee members were: P. Ruardij (chairman), R. Dapper, F. Eijgenraam, G.M. Manshanden, E. Embsen, W. Pool, B. Koster, R.X. de Koster, K. Booij as chairman of the User Committee. C.S. Blaauboer-de Jong took care of the minutes of Committee meetings.

The User Committee dealt with daily problems of computer users related to hard- and software. The Committee advised the director on the automation management within the institute. Committee members were: K. Booij (chairman, Chemical Oceanography and Marine Pollution), R. Dapper (CIA), J. Nieuwenhuis (Technical Services). H. Malschaert (BeWON), L.R.M. Maas (Physical Oceanography), J.H.F. Jansen (Geology), H. van der Veer (Coastal Systems), H.J. Witte (Pelagic Systems), A. Kok (Benthic Systems), M. Baas (Marine Biogeochemistry). The Editorial Office, the Reprographic Service, the Financial Service, and the Library received the Committee's papers. C.S. Blaauboer-de Jong was secretary of the Committee. The committee met five times in 1995.

In connection with the reorganization, as of 1 November one Computer Committee has been installed instead of both User Committee and Technical Committee. Members are computer experts and users. Committee members are: P. Ruardij (chairman), L.R.M. Maas, H. Malschaert, W. Pool, R. Dapper, E. Embsen and F. Eijgenraam. C.S. Blaauboer-De Jong is secretary of the Committee. In 1995 two meetings were held.

The Library

In 1995 a start was made with the computerization of the NIOZ library, by means of the Shared Cataloguing System on line via the Groningen University library. New acquisitions have been entered into the Shared Cataloguing System since March. In co-operation with the Groningen University Library a start has been made to enter the existing collection. This is accompanied by a reclassification of the book collection by the library committee. At the end of 1995 more than 50 per cent of the books and a minor part of the periodicals had been entered into the new system.

Access to the catalogue is via the Online Public access Catalogue (OPC). The NIOZ library has been entered as a separate directory into the catalogue of the Groningen University Library. The OPC also gives access to the files of many other libraries and to a number of Dutch databases. The OPAC is accessible via telnet on a computer in the library or elsewhere.

For the Interlibrary Lending System we use the Dutch Union Catalogue. This system automatically selects a library that has the book or periodical requested in stock. Via the same system we also receive lending requests from other libraries. Titles that have been entered into the Shared Cataloguing System are available via the Dutch Union Catalogue. As the part of our own collection in the Shared Cataloguing System increases, lending requests from other libraries will also increase.

A major part of our periodicals are acquired through exchange with other periodicals. Exchanges used to take place with the Netherlands Journal of Sea Research, the Netherlands Journal of Zoology and the NIOZ Annual Report. From late 1995 onwards, the NJSR is no longer available for exchange. The exchange agreements have either been terminated, or reduced to the Annual Report.

New subscriptions in 1995:
—Open
—Journal of Mass Spectrometry

—Organic Geochemistry
—Trends in Ecology & Evolution
—Oecologia
—Phytochemistry
—Lipids
—Energy & Fuels
—Aquatic Microbial Ecology

The book collection has been sorted out by the Library Committee. A number of dated and or irrelevant works have been removed from the collection or transferred to the University Library in Groningen. 175 new books have been acquired. The Library has stopped the purchase of 50 copies of Ph.D. theses and reprints of articles by NIOZ scientists for distribution. One copy of each publication is included in the collection.

There were 1025 loans and 1910 requests for loans from other libraries.

Editorial Office

—see 2. Publications and presentations

Reprographic Service

In the Reprographic Service more drawings are now produced with computers than on the drawing boards. This is a positive development, if only for the fact that it saves time. Assistance was also given to people who delivered drawing work or sketches on floppy disks, or existing drawings which needed digitizing. By using the flatbed scanner, graphical and cad software drawings were improved and corrected for publication.

The use of the copiers has decreased, especially since the introduction of the electronic registration system. Much use was made of the printing shop until the large press broke down. It remains doubtful whether it will be replaced. Large quantities of slides were produced for congresses, symposia and workshops.

Audio-visual Service

In 1995, relatively more work on posters and video recordings was carried out for Ph.D. students than in previous years. The group of ornithologists (T. Piersma) have again been able to follow their flocks of knots via a camera set-up. The film was edited for use by the University of Groningen (database: J. Van Gils, M. Tenty, A. Haven). For IMPACT-II, a camera set-up was arranged in the aquarium to record the work of S. Groenewold (co-operation: P. Van der Puyl, R. Lakeman, T. Kuip). To investigate the possibility of constructing an underwater camera to be used by M. Lavaleije, a visit was paid to Sony Nederland. This enabled J. Van Heerwaarden and M. Laan to construct a camera that has already given spectacular results.

This year there was an extraordinary interest in the NIOZ film 'Deposit Feeding', and copies have been sent to several institutions.

Based on a selection of posters, an exhibition was held in Den Helder of the history and activities at NIOZ (esp. marine electronics). More that 30 posters were made, such a three for JGOFS (Brest) and four for IFREMER. Such carefully composed posters help create a positive, clear and interesting picture of the research carried out at NIOZ.

5. Sociaal Jaarverslag

Photo: H. Hobbelink

ALGEMEEN

Zoals in het vorige jaarverslag is vermeld, heeft het bestuur de aanbevelingen van het organisatieadviesbureau Anderson Elffers Felix (&AEF) overgenomen om te komen tot een eenhoofdige directiestructuur. Op basis van het rapport van &AEF over de structuur van de wetenschappelijke afdelingen besloot het bestuur tot herindeling van de wetenschappelijke afdelingen. Daarbij werd het aantal teruggebracht van acht naar vijf en werd het beleidsrelevante en toepassingsgerichte onderzoek volledig in de afdelingen geïntegreerd. Tevens werd op aanbeveling van &AEF de financiële organisatie aangepast. De nieuwe organisatievorm werd geïmplementeerd op 1 juli 1995. Voor details wordt verwezen naar het bijgevoegde organogram.

Nadere advisering werd gevraagd betreffende de bedrijfsvoering en het financiële management. De financiële situatie van het instituut gaf reden tot bezorgdheid. Deze advisering gaf aanleiding tot het opstellen van een reorganisatieplan dat moet leiden tot financiële gezondmaking van het instituut. Het voorstel dat werd uitgewerkt (met de werknaam NIOZ-99) werd eind november aan NWO voorgelegd met het verzoek om financiële steun. NWO heeft zich begin 1996 bereid verklaard tot een eenmalige financiële injectie op voorwaarde dat de voorstellen voor reorganisatie in de bedrijfsvoering en heroriëntering op de wetenschappelijke koers onverkort worden doorgevoerd. Plannen hiervoor worden begin 1996 uitgewerkt. Hierbij zullen structurele bezuinigingen op de personele uitgaven gerealiseerd moeten worden. Inmiddels leeft het instituut sinds begin 1995 onder een strikt bezuinigingsregime dat de komende jaren zal moeten worden voortgezet.

BESTUUR EN WETENSCHAPCOMMISSIE

Bestuur Stichting NIOZ

Per 12 januari 1995 is Prof.dr. J.A. Battjes teruggetreden en werd Prof.dr. K. Verhoeff benoemd tot voorzitter van het bestuur.
Per 31 december 1995 was het bestuur als volgt samengesteld:

Prof.dr. K. Verhoeff, voorzitter	Wageningen
Prof.dr. R.H. Drent	Zoölogisch Laboratorium, Rijksuniversiteit Groningen
Prof.ir. H.P. van Heel	Hoechst Holland NV, Vlissingen
Prof.dr. J.G. Kuenen	Vakgroep Microbiologie en Enzymologie, Technische Universiteit Delft
Ktz.b.d. Th.G. Loeber	Hilversum

Het bestuur kwam in het verslagjaar 1995 viermaal met de directie in vergadering bijeen; op 12 januari en 7 maart te Amsterdam en op 14 - 15 juni en 2 - 3 november op Texel. De vergaderingen werden namens de algemeen directeur NWO bijgewoond door Dr. J. Dijkhof. Genotuleerd werd door mevrouw C.S. Blaauboer-de Jong.

In verband met de besluitvorming betreffende de reorganisatie van het instituut kwam het bestuur bovendien bijeen op 3 april, 16 mei en 19 december.

Wetenschapcommissie NIOZ

De Wetenschapcommissie adviseert het Bestuur en de Directie over het algemene wetenschappelijk beleid van de Stichting en het Instituut, zij evalueert periodiek het wetenschappelijk programma en zorgt voor de wetenschappelijke beoordelingsprocedure van de eigen NIOZ OIO-voorstellen.

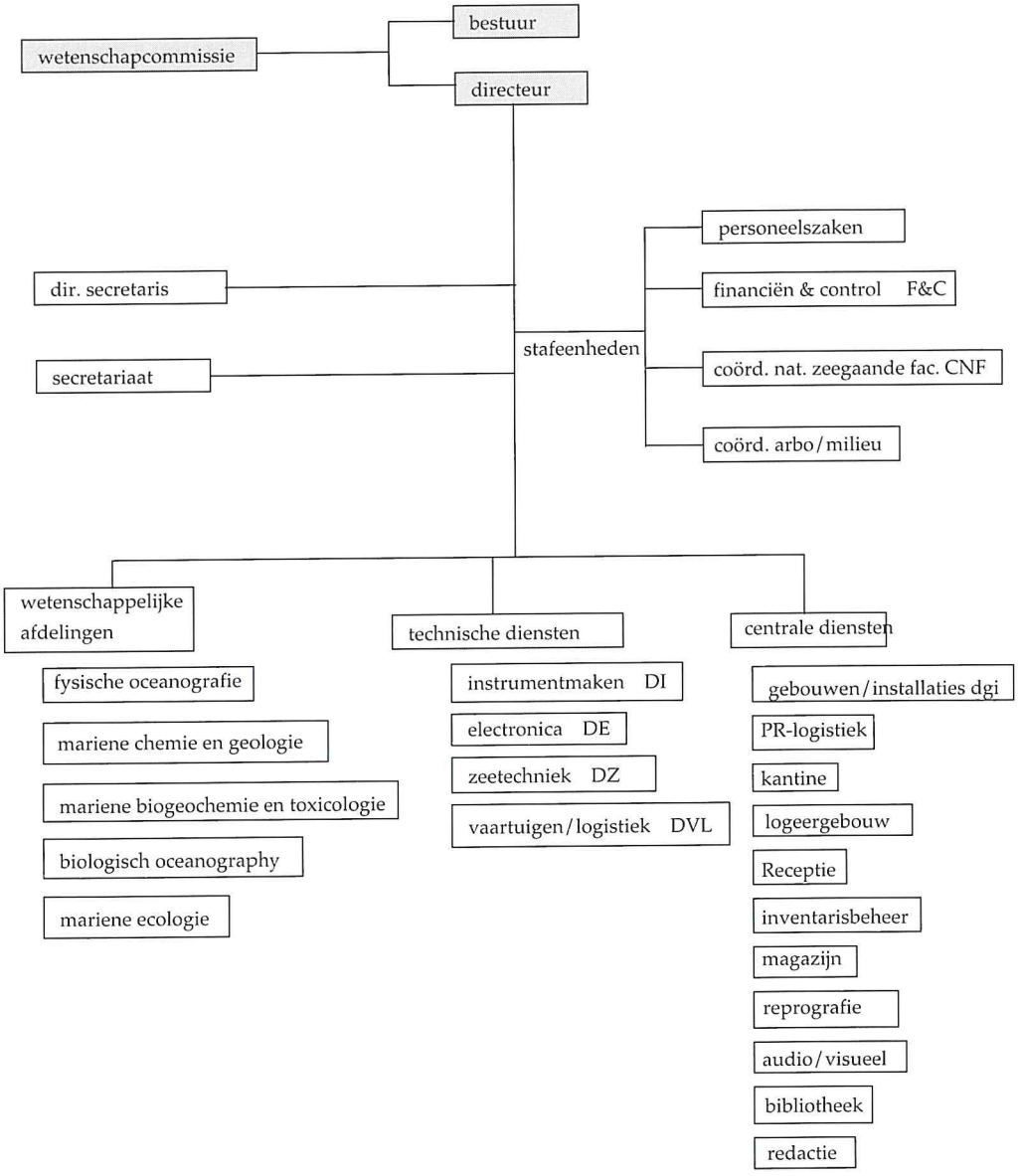
De Wetenschapcommissie was per 31 december 1995 als volgt samengesteld:

Prof.dr. R.H. Drent, voorzitter	Zoölogisch Laboratorium, Rijksuniversiteit Groningen
Prof.dr. J.C. Duinker	Institut für Meereskunde, Universität Kiel, Duitsland
Prof.dr.ir. G.J.F. van Heijst	Afd. Technische Natuurkunde, Technische Universiteit, Eindhoven
Prof.dr. R.A. Prins	Vakgroep Microbiologie, Rijksuniversiteit Groningen
Prof.dr. V. Smetacek	Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Duitsland
Prof.dr. W.M. Warwick	Plymouth Marine Laboratory, Engeland
Prof.dr. G. Wefer	Geowissenschaften, Universität Bremen, Duitsland
Prof.dr. W.J. Wolff	Instituut voor Bos- en Natuuronderzoek, Wageningen

De jaarlijkse bijeenkomst van de Wetenschapcommissie werd gehouden op 18 - 19 april. Aan de vergadering werd deelgenomen door de directeur Prof.dr. W.G. Mook. De verslaglegging werd verzorgd door J.W. Rommets en W.G. Mook.

De afdeling Geologie / Geochemie presenteerde zich aan de Commissie.

ORGANOGRAM



PERSONEELSLIJST 31-12-95

DIRECTIE

Mook W.G. *Prof. dr.*	34.6 uur	directeur
Rietveld M.J. *Drs.*		directie-secreataris
Directiesecretariaat		
Hart-Stam J.M.G.		dir. secretaresse
Blaauboer-de Jong C.S.	30.4 uur	dir. secretaresse
Bol-den Heijer A.C.	28.2 uur	dir. secretaresse

STAFEENHEDEN

Personeelszaken	
Vooys P.C.	hoofd
Financiën en control	
Huffnagel E. *Ir.*	adviseur/hoofd ad interim

Luursema C.W. *Drs.*		hoofd	tot 15-10
Arkel M.A. van *Drs.*		projectcontroller	
Wernand-Godee I.		medewerker project-administratie	
Bruin D.J.		medewerker financiële administratie	
Keijser A.		medewerker financiële administratie	
Spel M.M.	19.0 uur	medewerker financiële administratie	
Porto S.W. de		medewerker inventarisatieadministratie	
Nationale zeegaande faciliteiten (MRF)			
Bergen Henegouw C.N. van *Drs. Ing.*		coördinator	
Arbo- en milieuzaken			
Rommets J.W.		coördinator	

CORE PROJECT OFFICE (LOICZ/IGBP)

Pernetta J.C. *Dr.*		director	
Boudreau P.R. *Drs.*		project scientist	m.i.v. 01-01
Zyp M. van der *Drs.*		junior data-analist	m.i.v. 01-09
Lunter S.M. *Drs.*		office-administrator	
Jourdan M.T.	16 uur	administratief medewerkster	m.i.v. 01-02

WETENSCHAPPELIJKE AFDELINGEN

AFDELING FYSISCHE OCEANOGRAFIE

Ridderinkhof H.J. *Dr.*		waarnemend hoofd	
Veth C. *Drs.*		senior onderzoeker	
Zimmerman J.T.F. *Prof. dr.*	26.6 uur	senior onderzoeker	
Aken H.M. van *Dr.*		senior onderzoeker	
Maas L.R.M. *Dr.*		senior onderzoeker	
Haren J.J.M. van *Dr.*		post-doc NWO/VvA	
Schramowski G.P. *Dr.*		project-onderzoeker NWO/GOA	m.i.v. 01-10
Shimwell S.J. *Drs.*		project-onderzoeker	tot 01-07
			m.i.v. 01-09
			tot 01-12
Bruin T.F. de *Drs.*		datamanager MRF	
Toorn R. v.d. *Ir.*	32.0 uur	OIO NIOZ	tot 01-11
Lam F.P.A. *Drs.*	32.0 uur	OIO NIOZ	
Wilpshaar J.M.R. *Ir.*		OIO NWO/BOA	m.i.v. 01-02
Schrier G. van der *Drs.*		OIO NWO/GOA	m.i.v. 16-04
Beerens S.P. *Drs.*		OIO NWO/GOA	tot 08-07
Eijgenraam F.		automatiseringsdeskundige	
Wernand M.R.		senior onderzoekmedewerker	
Ober S. *Ing.*		senior onderzoekmedewerker	
Manuels M.W.		onderzoekmedewerker	
Hiehle M.A.		senior laboratoriummedewerker	
Koster R.X. de		senior laboratoriummedewerker	
Thieme J. *Ing.*		fysisch assistent (project-)	

AFDELING MARIENE CHEMIE EN GEOLOGY

Helder W. *Dr.*		hoofd	
Raaphorst W. van *Dr. ir.*		onderzoeker	
Baar H.J.W. de *Prof. dr. ir.*	30.4 uur	senior onderzoeker	
Eisma D. *Prof. dr.*		senior onderzoeker	
Weering T.C.E. van *Dr.*		senior onderzoeker	
Jansen J.H.F. *Dr.*		senior onderzoeker	
Bennekom A.J. van *Drs.*		senior onderzoeker	
Ben Khelifa L.M. *Dr.*		post-doc NWO/VvA	tot 15-04
Brummer G.J.A. *Dr.*		post-doc NIOZ	tot 16-09
			m.i.v. 15-11
Timmermans K.R. *Dr.*		post-doc NWO/GOA	
Hey H. de *Drs.*	30.4 uur	onderzoeker (project-) NWO/VvA	
Stigter H.C. de *Drs.*		gewetensbezwaarde	tot 15-02
Lohse L. *Drs.*		OIO NIOZ	m.i.v. 01-07
Gipp H.J.W. *Drs.*		OIO NIOZ	
Beks J.P. *Drs.*		OIO NIOZ	
Vreeze J.F.M de *Ir.*	30.4 uur	OIO NIOZ	tot 01-04
Leeuwe M.A. van *Drs.*	34.2 uur	OIO NIOZ	tot 01-12

Haas H. de *Drs.*		OIO NWO/VvA	
Bakker D.C.E. *Ir.*		OIO NOP	tot 01-05
Wilde H.P.J. de *Ir.*		OIO NOP	tot 01-05
Wiebinga C.J. *Drs.*	30.4 uur	OIO NWO/VvA	
Löscher B.M. *Drs.*		OIO NWO/GOA	
Majoor A.A.J. *Drs.*		OIO NWO/VvA	tot 01-09
Gaast S.J. v.d.		wetenschappelijk assistent	
Vaars A.J.		applicatietechnicus	
Nolting R.F.		senior onderzoekmedewerker	
Kloosterhuis H.T.		senior onderzoekmedewerker	
Ooijen J.C. van		senior onderzoekmedewerker	
Bakker K.M.J.		onderzoekmedewerker	
Malschaert H. *Ing.*		onderzoekmedewerker	
Boer W. *Ing.*		onderzoekmedewerker	
Iperen J. van	16.0 uur	senior laboratoriummedewerker	
Kalf J.		laboratoriumassistent	
Okkels E.	32.0 uur	laboratoriummedewerker	tot 01-07
Koutrik A. van		laboratoriummedewerker	
Witte A.	19.0 uur	project-analist	
Koning E. *Ing.*		analist NWO/VvA	tot 15-11
		toegev. project-onderzoeker	m.i.v. 15-11
Jong J.T.M. de		laboratoriumassistent	tot 01-05
		project-assistent NWO/GOA	m.i.v. 01-05
Jong E. de		laboratoriumassistent (project)	
Das J.H. den		laboratoriumassistent (project-)	m.i.v. 20-03

AFDELING MARIENE BIOGEOCHEMIE EN TOXICOLOGIE

Leeuw J.W. de *Prof. Dr.*		hoofd	
Everaarts J.M. *Dr.*		senior onderzoeker	
Sinninghe Damsté J.S. *Dr. ir.*	34.2 uur	senior onderzoeker	
Boon J.P. *Dr.*		senior onderzoeker	
Booy K. *Dr.*		onderzoeker	
Koster J. *Dr.*		post-doc NWO/pionier	tot 01-08
Versteegh G.J.M. *Dr.*		post-doc NWO/GOA	
Kok M.D. *Drs.*		OIO NIOZ/pionier	17-01
Koopmans M.P. *Drs.*		OIO NIOZ	tot 31-12
Mensink B.P. *Ir.*		OIO NIOZ	
Schanke A. van *Ir.*		OIO NIOZ	m.i.v. 01-09
Schouten S. *Ir.*		project-onderzoeker NWO	
		/pionier	tot 01-11
Sleiderink H.M. *Ir.*		project-onderzoeker	m.i.v. 24-04
			tot 24-07
			m.i.v. 24-8
			tot 24-11
Hold I.M. *Drs.*		OIO NWO/pionier	
Heemst J.D.H. van *Ir.*		OIO NWO/VvA	
Kaam H. van *Drs.*		OIO/NWO/GOA	
Pool W.G.		wetenschappelijk assistent	
Hillebrand M.T.J.		senior onderzoekmedewerker	
Baas M.		onderzoekmedewerker	
Rijpstra W.I.C.	19.0 uur	onderzoekmedewerker	
Dekker M.H.A.	36.0 uur	laboratoriumassistent	
Lewis W.E.	28.0 uur	laboratoriummedewerker	
Weerlee E.M. van		laboratoriummedewerker	
Fischer C.V. *Drs.*	28.0 uur	laboratoriummedewerker	

AFDELING BIOLOGISCHE OCEANOGRAFIE

Fransz H.G. *Dr. ir.*		waarnemend hoofd	
Baars M.A. *Dr.*		senior onderzoeker	
Klein Breteler W.C.M. *Dr.*		senior onderzoeker	
Vosjan J.H. *Dr.*		senior onderzoeker	
Veldhuis M.J.W. *Dr.*		senior onderzoeker	
Duyl F.C. van *Dr.*		senior onderzoeker	
Riegman R. *Dr.*		senior onderzoeker	
Ruardij P. *Drs.*		onderzoeker	
Kuipers B.R. *Dr.*		onderzoeker	
Hansen F.C. *Dr.*		post-doc NIOZ	
Boelen P. *Drs.*		OIO NIOZ	m.i.v. 01-01
Buitenhuis E.T. *Ir.*		OIO NWO/VvA	

Embsen E.G.M. *Ing.*		automatiseringsdeskundige	
Kraay G.W.		senior onderzoekmedewerker	
Pauptit E.		senior onderzoekmedewerker	
Kop A.J. *Ing.*		onderzoekmedewerker	
Oosterhuis S.S.		onderzoekmedewerker	
Noordeloos A.A.M.		senior laboratoriummedewerker	
Noort G.J. van		senior laboratoriummedewerker	
Gonzalez S.R.		senior laboratoriummedewerker	
Witte H.J.		senior laboratoriummedewerker	
Schogt N.		laboratoriummedewerker	

AFDELING MARIENE ECOLOGIE

Lindeboom H.J. *Dr.*		afdelingshoofd	
Meer J. van der *Drs.*		senior onderzoeker	
Wilde P.A.W.J. de *Prof. dr.*		senior onderzoeker	
Beukema J.J. *Dr.*		senior onderzoeker/hoofdredacteur NJSR	
Bak R.P.M. *Prof. dr.*		senior onderzoeker	
Spaargaren D.H. *Dr.*		senior onderzoeker	
Fonds M. *Dr.*		senior onderzoeker	
Cadée G.C. *Dr.*		senior onderzoeker	
Veer H.W. van der *Dr. ir.*		senior onderzoeker	
Piersma T. *Dr.*		senior onderzoeker	
Wolf P. de *Dr.*		gastonderzoeker	
Bergman M.J.N. *Ir.*		onderzoeker	
Duineveld G.C. *Drs.*		onderzoeker	
Daan R. *Dr.*		onderzoeker (project-)	
Dekker R. *Drs.*		onderzoeker	
Ens B.J. *Dr.*		project-onderzoeker	m.i.v. 01-02 tot 01-03
Berg A.J. van den *Drs.*	24.0 uur	project-onderzoeker	m.i.v. 01-02
Brugge J. van den *Drs.*		project-onderzoeker	m.i.v. 01-12
Philippart C.J.M. *Dr.*		project-onderzoeker	
Zuur A.F. *Drs.*		project-onderzoeker	tot 01-07
Holtmann S.E. *Drs.*	28.0 uur	project-onderzoeker	
Lavaleye M.S.S. *Drs.*		project-onderzoeker	m.i.v. 01-08
Witbaard R. *Drs.*	38.0 uur	project-onderzoeker	m.i.v. 01-04 tot 01-10
Santbrink J.W. van *Drs.*		toegevoegd projectonderzoeker	
Camphuysen C.J.	19.0 uur	wet. assistent (project-)	m.i.v. 01-07 tot 31-12
Gast G.J. *Drs.*		OIO NIOZ	
Hondeveld B.J.M. *Drs.*	34.2 uur	OIO NIOZ	tot 01-02
Goeij P.J. de *Drs.*		OIO NIOZ	
Bolle L.J. *Drs.*	34.2 uur	OIO NIOZ	tot 01-08
Slomp C.P. *Ir.*		OIO NOP	tot 01-05
Osinga R. *Drs.*		OIO NOP	tot 01-05
Honkoop P.J.C. *Drs.*		OIO NOP	
Brussaard C.P.D. *Drs.*		OIO EU	tot 01-01-1996
Tahey T.M. *Drs.*		OIO EG	tot 15-10
Walker P.A. *Drs.*	36.0 uur	OIO NAM	
Boon A.R. *Ir.*		OIO NWO/VvA	
Dapper R.		automatiseringsdeskundige	
Berghuis E.M.		senior onderzoekmedewerker	
Nieuwland G.		senior onderzoekmedewerker	
Hegeman J.		onderzoekmedewerker	
Duiven P.		onderzoekmedewerker	
Kok A.		onderzoekmedewerker	
Mulder M.		onderzoekmedewerker	
Witte J.IJ.		onderzoekmedewerker	
Puyl P. van der		laboratoriummedewerker	
Bruin W. de		laboratoriummedewerker	
Zuidewind J.		laboratoriummedewerker	
Smit J.P.C.	33.0 uur	techn. wetensch. programmeur	m.i.v. 01-01 tot 01-01-1996
Kracht B. *Drs.*	19.0 uur 24.0 uur	project-assistent	tot 01-07 m.i.v 01-08
Belgers J.J.M.	24.0 uur	project-analist	tot 03-09
Weele J.A. van der		gewetensbezwaarde	tot 05-02
		project-assistent	m.i.v. 06-02 tot 01-10 m.i.v. 01-11
Kwast D.		project-assistent	tot 01-12
Winter C.		project-assistent	tot 21-02

CENTRALE DIENSTEN

Abs E. van *Ing.*		hoofd
Dienst gebouwen en installaties		
Schilling F.J.		hoofd
Alkema P.R.	35.15 uur	med. werktuigbouw
Groot S.P.	30.4 uur	med. werktuigbouw
Kuip T.		med. werktuigbouw
Lakeman R.	20.0 uur	med. werktuigbouw
Daalder R.M.		med. houtbewerking
Witte R.J.C.		med. houtbewerking
Brondsema A.		med. energietechniek
PR-logistiek		
Nieuwenhuizen J.M.		hoofd
Kantine		
Spigt H.		hoofd
Logeergebouw 'In Den Potvis'		
Steenhuizen G.H.		beheerder
Borkulo T.C. van	19.0 uur	medewerkster
Receptie		
Kikkert A.	20.0 uur	telefoniste/receptioniste
Jourdan M.T.	20.0 uur	telefoniste/receptioniste
Starink J.M.	19.5 uur	telefoniste/receptioniste
Inventarisbeheer		
Porto S.W. de		medewerker
Magazijn		
Ran A.		hoofd
Gieles S.J.M.		medewerker
Reprografische afdeling		
Aggenbach R.P.D.		eerste medewerker
Verschuur B.	35.15 uur	medewerker
Nichols R.C.		medewerker
Graaf A.C. de	30.0 uur	medewerker
Audiovisuele middelen		
Hart W.	24.0 uur	medewerker
Bibliotheek		
Brouwer A.		hoofd
Bruining-Du Porto M.	31.5 uur	medewerker
Zonnenberg G.	35.15 uur	administratief medewerker
Redactie		
Beukema J.J. *Dr.*		hoofdredacteur
Bak-Gade B.	20.0 uur	assistent redacteur
Mulder-Starreveld J.P.	28.5 uur	redactie-assistente
Barten-Krijgsman N.	15.2 uur	redactie-assistente
Hobbelink H.		grafisch ontwerper

TECHNISCHE DIENSTEN

Bakker C.L.		hoofd	
Bonne E.		medewerker (detachering)	
Instrumentmaken			
Boekel H.J.		hoofd	
Keijzer E.J.H.		medewerker	
Heerwaarden J. van		medewerker	
Kuiken N.E.		medewerker	tot 01-09 m.i.v. 01-10
Electronica			
Groenewegen R.L. *Ing.*		hoofd	
Koster B. *Ing.*		plv. hoofd	
Franken H. *Ing.*		hoger electronicus	
Laan M.		hoger electronicus	
Nieuwenhuis J.		middelbaar electronicus	
Derksen J.D.J.		electronicus Pelagia	
Manshanden G.M.	30.4 uur	automatiseringsdeskundige	
Zeetechniek			
Porto H.H. de		hoofd	
Schilling J.		plv. hoofd	
Bos E.B.M.		eerste medewerker	
Wijsman M.A.		medewerker	tot 01-02
Willems C.		medewerker	
Polman W.		medewerker	
Bakker M.C.		medewerker	

Blom J.J.	medewerker	
Bakker J.A.	medewerker	m.i.v. 01-07 tot 01-10
Wuis L.M.	medewerker	m.i.v. 17-10
Boom L.	medewerker	m.i.v. 01-10 tot 31-12
Vaartuigen en logistiek		
Buisman T.C.J.	hoofd	
Zwieten C. van	med. naut. zaken	
Eelman A.	chauffeur (detachering)	
Visser M.	medewerker	m.i.v. 26-06 tot 18-08
Souwer A.J.	gezagvoerder Pelagia	
Groot J.C.	1e stuurman Pelagia	
Duyn M.D. van	2e stuurman Pelagia	
Pieterse J.M.	hoofdwerktuigkundige Pelagia	
Seepma J.	1e werktuigkundige Pelagia	
Kalf J.J.	2e werktuigkundige Pelagia	
Grisnicht P.W.	scheepstechnicus Pelagia	
Saalmink P.W.	scheepstechnicus Pelagia	
Stevens C.T.	scheepstechnicus Pelagia	
Koomen W.J.M.	scheepskok Pelagia	
Adriaans E.J.	schipper Griend	
Star C. van der	schipper Navicula	
Tuntelder J.C.	scheepstechnicus/kok Navicula	
Schagen P.J.	machinist/motordrijver Navicula	
Jongejan W.P.	komvisser	

ARBEIDSVOORWAARDEN

Algemeen

Het overleg over de primaire, collectieve arbeidsvoorwaarden in de sector O&W wordt gevoerd door de Minister van Onderwijs, Cultuur en Wetenschappen met de vier centrales van overheids- en onderwijspersoneel.

De voor NIOZ-medewerkers geldende, met name secundaire en tertiaire, arbeidsvoorwaarden zijn opgenomen in de CAR (Collectieve Arbeidsvoorwaardenregeling NWO/FOM/SMC/NIOZ) en in de Arbeidsvoorwaardenregeling van de Stichting NIOZ.

De CAR, die op 1 september 1993 in werking trad, is het resultaat van de onderhandelingen inzake de arbeidsvoorwaarden tussen de vakbonden en de 4 NWO-werkgevers.

Primaire arbeidsvoorwaarden

In het laatste kwartaal van 1995 is tussen de Minister van Onderwijs, Cultuur en Wetenschappen en de centrales van overheidspersoneel overeenstemming bereikt over de arbeidsvoorwaarden die betrekking hebben op de periode 1 april 1995 tot 1 april 1996.

De salarissen van het personeel dat werkzaam is binnen deze sector zijn per 1 april 1995 verhoogd met 0,65% en per 1 april 1996 met 1,1% zodat uiteindelijk een structurele verhoging wordt toegepast van 1,75% (per 1 januari 1995 zijn de salarissen als gevolg van het vorige onderhandelingsresultaat met 0,5% verhoogd).

Deze salarisverhoging werkt door naar de onder de bezoldiging vallende toelagen en naar de uitkeringen.

DECENTRALE ARBEIDSVOORWAARDENMAATREGELEN

Verlenging SOP-regeling (Seniorenregeling Onderwijs Personeel)

De SOP-regeling houdt in dat medewerkers vanaf 57 jaar in aanmerking kunnen komen voor een kortere werkweek tegen een beperkte vermindering van het salaris. Men kan daarbij kiezen uit verschillende varianten. De regeling werd verlengd tot 1 januari 1996. Een voorstel van de werkgevers NWO, FOM, SMC, NIOZ om de regeling ook na 1 januari 1996 voort te zetten onder de voorwaarde dat er een koppeling zou plaatsvinden met de VUT-gerechtigde leeftijd, werd door de vakbonden in het Georganiseerd Overleg van december niet overgenomen. Inmiddels is echter de regeling onder de oude condities verlengd tot 1 mei 1996.

Zes medewerkers maken gebruik van deze regeling.

Regeling ouderschapsverlof

Deze regeling biedt aan ouders van kinderen die jonger zijn dan 4 jaar de gelegenheid om voor maximaal 50% van de werktijd ouderschapsverlof te genieten. Over de verlofuren wordt 75%

van het salaris doorbetaald. Er zijn flexibele verlofvormen mogelijk. Voorwaarde is dat het verlof binnen een tijdvak van 12 maanden opgenomen moet worden. In het verslagjaar hebben vier medewerkers ouderschapsverlof genoten.

Kinderopvang

Het contract dat het NIOZ heeft gesloten met de Stichting Kinderdagverblijf Texel houdt in dat het NIOZ de beschikking heeft over tien dagdelen 'kinderopvang'. Met de Ondernemingsraad zal in 1996 overleg worden gevoerd of de regeling kinderopvang in de huidige vorm zal worden gecontinueerd. Medewerkers die aan de *'overkant'* wonen, kunnen namelijk nadeel ondervinden indien zij hun kind willen plaatsen op het kinderdagverblijf op Texel of elders willen onderbrengen.

OVERIGE MAATREGELEN / WIJZIGINGEN

Wet op de Identificatieplicht

Elke werknemer is in het kader van deze wet verplicht om een kopie van een geldig identiteitsbewijs bij de werkgever in te leveren. De wet, die in werking trad op 1 juni 1994, bood de werknemer de gelegenheid om voor 1 juni 1995 aan deze verplichting te voldoen. Bij niet-naleving hiervan, was de werkgever verplicht om na 1 juni een loonbelastingpercentage toe te passen van 60%. Deze maatregel behoefde echter door het NIOZ niet getroffen te worden daar alle medewerkers voor genoemde datum een kopie van het desbetreffende document hadden ingeleverd.

Werknemersverzekeringen / wachtgeldhiaat

In de afgelopen jaren zijn er ontwikkelingen gaande die er toe zullen leiden dat in de nabije toekomst zowel het overheidspersoneel als de werknemers in de marktsector overeenkomstige rechten en plichten zullen krijgen ten aanzien van de werknemersverzekeringen. Een aantal veranderingen hiertoe is inmiddels in 1995 ingesteld. Per 1 januari zijn de zogenaamde 'pseudo' premies voor de ZW, WW en WAO ingevoerd. Gelijktijdig is de 'vereveningsbijdrage' afgeschaft (een korting die op het salaris van de ambtenaar werd toegepast ter compensatie van het voordeel dat de ambtenaar genoot omdat hij/zij geen sociale premies betaalde).

Een belangrijke wijziging in geval er sprake is van (langdurige) ziekte is de invoering van een arbeidsongeschiktheidsregeling per 1 januari 1996 die op praktisch dezelfde wijze wordt uitgevoerd als de WAO. Een gevolg hiervan kan zijn dat werknemers die partieel arbeidsongeschikt raken na verloop van tijd het risico lopen een aanzienlijk deel van het inkomen te verliezen indien zij er niet in slagen een passende baan te vinden voor het percentage dat men nog arbeidsgeschikt is bevonden. Met name de jongere werknemers die over weinig dienstjaren beschikken, behoren tot deze risicogroep. Ter dekking van het zogenaamde 'wachtgeldhiaat' dat in deze situaties kan ontstaan, heeft de stichting NIOZ tezamen met NWO en SMC in de maand december een collectieve verzekering gesloten met verzekeraar OHRA.

REORGANISATIE 1 JULI 1995

De reorganisatie die per 1 juli 1995 werd ingevoerd, richtte zich voornamelijk op de structuur van het instituut en niet op de omvang van de formatie. De herschikking had betrekking op de directiestructuur, de indeling van de wetenschappelijke afdelingen en op de financiële structuur van het instituut (zie algemeen).

Een aantal functies kwam te vervallen en sommige functies werden nieuw in de organisatiestructuur opgenomen. Aan medewerkers van wie de functie verviel of sterk inhoudelijk wijzigde, werd een passende functie aangeboden.

Alle medewerkers werden in de gelegenheid gesteld hun belangstelling kenbaar te maken voor een andere functie dan die zij op dat moment vervulden.

In het tweede kwartaal werd de plaatsingsprocedure uitgevoerd. Met de medewerkers werden door het lijnmanagement plaatsingsgesprekken gevoerd waarin zij in kennis werden gesteld van hun plaats en functie in de nieuwe organisatiestructuur met bekendmaking van het bij de functie behorende vastgestelde, organieke schaalniveau. Deze gesprekken werden nadien schriftelijk bevestigd.

Er was een Begeleidingscommissie Plaatsing ingesteld met als taak bezwaren van medewerkers ten aanzien van (her)plaatsing in behandeling nemen en hierover advies uitbrengen aan de directie of aan het bestuur. Deze commissie was samengesteld uit een wetenschappelijk onder-

zoeker, een onderzoekassistent, een medewerker van de ondersteunende afdelingen en een 'ambtelijk' secretaris. De commissie heeft 3 bezwaren in behandeling genomen. Eén bezwaar is voorgelegd aan de Adviescommissie Personeelsaangelegenheden NWO.

ARBEIDSOMSTANDIGHEDEN

ARBO

Door het Nederlands Instituut voor Arbeidsomstandigheden (NIA) is in 1995 een cursus gegeven over het Inspectie Plus Pakket (IPP) met behulp waarvan de (verplichte) jaarlijkse risico-inventarisatie en -evaluatie kan worden uitgevoerd. Deze inventarisatie en evaluatie is vervolgens in het derde kwartaal afgerond.

Per 1 juli is in het kader van de reorganisatie een coördinator Arbo- en Milieuzaken benoemd. Tevens is er een Arbo-Milieucommissie ingesteld en een Arbo-Milieuwerkgroep. Eerstgenoemde commissie heeft een initiërende, coördinerende en adviserende functie met betrekking tot Arbo- en Milieuaangelegenheden. Deze commissie is niet verantwoordelijk voor het Arbo-Milieubeleid. Deze verantwoordelijkheid valt onder het lijnmanagement. De Arbo-Milieuwerkgroep heeft als taak de risico-inventarisatie uit te voeren met behulp van het IPP-pakket en de resultaten hiervan te bespreken binnen de afdeling en met de coördinator Arbo-en Milieuzaken.

Voor nadere informatie wordt verwezen naar het Arbo- en Milieujaarverslag.

Bedrijfsgezondheidszorg

De veranderde regelgeving op het gebied van de arbeidsongeschiktheidsuitkeringen en de terugdringing van het ziekteverzuim, maakt het voor werkgevers noodzakelijk vroegtijdig maatregelen te nemen teneinde een spoedige werkhervatting van de zieke werknemer te bevorderen. Zo zal er na een periode van 6 weken arbeidsongeschiktheid in overleg met de zieke werknemer en de bedrijfsarts een *terugkeerplan* moeten worden opgesteld. Het ABP controleert de begeleiding door op vastgestelde momenten schriftelijke rapportages te vragen bij de werkgever. Regelmatig vindt er hierover in het Sociaal Medisch Team overleg plaats met de bedrijfsarts.

Ziekteverzuim

In 1994 was er nog sprake van een lichte stijging van het ziekteverzuim ten opzichte van het vorige jaar. In 1995 daalde het totale ziekteverzuim met 0,3% tot 4,1%.

Deze afname geldt zowel voor het wetenschappelijk als het niet-wetenschappelijk personeel. Het ziekteverzuim onder de mannelijke personeelsleden ligt over het algemeen iets lager dan bij de vrouwelijke personeelsleden.

	WP	M	V	NWP	M	V
1994	2,4	1,5	5,5	5,4	5,6	4,7
1995	1,47	1,31	2,16	5,16	4,98	5,82

OVERLEG

Uitvoeringsregelingen

In 1995 zijn er na overleg met de Ondernemingsraad twee nieuwe uitvoeringsregelingen tot stand gekomen: de regeling Personeelsbeoordeling en de regeling Functioneringsgesprekken.

Bij de regeling Personeelsbeoordeling waren Ondernemingsraad en Directie om voor hun moverende redenen overeengekomen te kiezen voor een beoordelingssysteem op basis van *niet-periodiciteit*. In later stadium is dit herzien. Na positieve uitgebrachte beoordelingen kan in het vervolg eventueel worden volstaan met een zogenaamde *verkorte beoordelingsprocedure*. Dit kan tijdens het periodieke functioneringsgesprek aan de orde worden gesteld.

Hoewel er in het verslagjaar, wanneer daar aanleiding toe was, al functionerings- en beoordelingsgesprekken zijn gehouden, zal de systematische personeelsbeoordeling aan het einde van het 1e kwartaal 1996 worden ingevoerd nadat de desbetreffende uitvoeringsregeling door het Algemeen Bestuur van NWO is goedgekeurd. Tevens zal er aan het personeel en de afdelingshoofden voorlichting worden gegeven over het systeem van personeelsbeoordeling en het houden van functioneringsgesprekken.

Georganiseerd Overleg

Aan het GONWO (Georganiseerd Overleg NWO) nemen deel de centrales van overheidspersoneel ABVA/KABO, AC, CFO, CMHF en de werkgevers NWO, FOM, SMC en NIOZ. In het

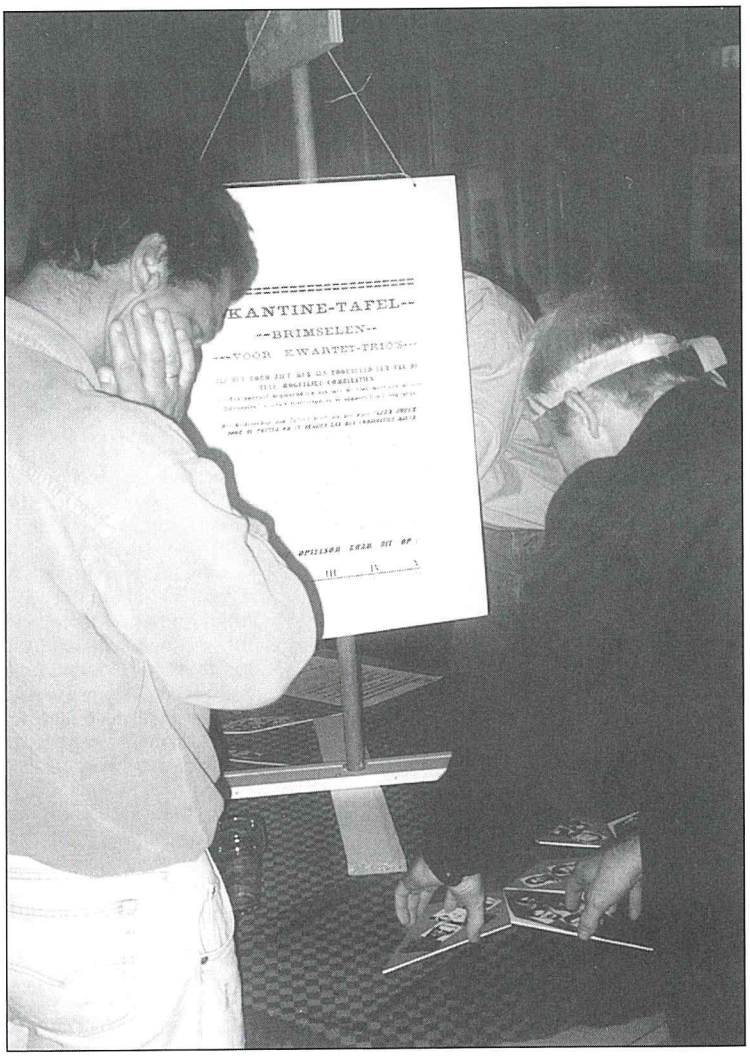
GONWO wordt overleg gevoerd over algemene (personele) aangelegenheden ten behoeve van het personeel dat in dienst is van voornoemde werkgevers.

PERSONEELSVERENIGING

Traditie getrouw was er wederom een pannekoekenfeest, met min of meer deskundig gebakken pannekoeken in de range dun tot zeer dik en lichtbruin tot gitzwart. Het verbaast het bestuur dat steeds vrijwel alles wordt opgegeten en alle kinderen het festijn overleven. Ook dit jaar, net als in 1993 was er tussen het eten door een voorstelling van 'Het afgestofte poppentheater' van Ila van der Pouw. Ila deed de hele uitvoering in haar eentje, ze zet ook zelf de decors in elkaar en weet de kinderen en ouders te boeien met haar enthousiasme en leuke vondsten in haar spel.

De toneeluitvoering van 'Comedia de la NIOZ' werd een jaar uitgesteld. Door vaartochten, vakanties en ziekte van diverse spelers bleef er onvoldoende tijd over om een goed stuk ook goed op de planken te zetten. We zijn heel wat gewend van onze spelers en kijken nu uit naar de voorstelling in 1996.

Op 19 oktober werd er een alternatieve sportdag georganiseerd in het partycentrum 'Calluna' op Texel bij de Koog. Het PV-bestuur had te kennen gegeven zich wat 'organisatiemoe' te voelen en had een beroep gedaan op het aanwezige 'NIOZ' intellect bij te dragen met frisse ideeën. Bij aankomst werden we verrast met koffie en gebak. Via een loting werd men ingedeeld in groepen van maximaal 8 personen. E. Bonne had allerlei puzzels, opdrachten met strikvragen bedacht en gemaakt, waardoor menigeen in de val werd gelokt. Enige kennis van wiskunde was niet overbodig. De fanatici onder ons konden zich weer eens flink uitleven met zulke opdrachten. De deelnemers zaten diep over de opdrachten heen gebogen en van verre kon je de hersens horen kraken. Zelfs over de uitslagen werd gediscussieerd. Volgens enkele deelnemers zouden er meer antwoorden mogelijk zijn geweest en dan is het zwaar wanneer de 1e prijs (een slagroomtaart) naar de buren gaat. Na het uitreiken van de prijzen sloten we af met een gezellig etentje en ging iedereen weer richting huis.



De speler met het hoofdlint probeert taartpunt combinaties uit, terwijl iemand van een ander team de kunst afkijkt.
Foto: M.R. Wernand.

ACRONYMS USED IN THIS ANNUAL REPORT

ACC	Antarctic Circumpolar Current
ACS	American Chemical Society
ADCP	Acoustic Doppler Current Profiler
AGU	American Geophysical Union-3
ALBEX	Autonomous Lander for Biological Experimentation
AMS	Accelerator Mass Spectrometry
ARA-KNAW	Academische Raad voor de Aardwetenschappen KNAW
ARGOS	a satellite location and data collection system
ASLO	American Society of Limnology and Oceanography
ASMO	Assessment and Monitoring committee according to the Oslo and Paris Conventions for the prevention of marine pollution (OSPARCOM)
AWI	Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
BCRS	Beleids Commissie Remote Sensing Netherlands Remote Sensing Board
BELS	Benthic Links and Sinks in North Sea Nutrient Cycling
BOA	Gebiedsbestuur voor de Biologische, Oceanografische en Aardwetenschappen Foundation for Biological, Oceanographic and Earth Sciences
BOBO	Bottom benthic boundary lander
BOLAS	Bottom Lander System
CCD	Carbonate Compensation Depth
CIESM	Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranée
CLIMAP	Climate, Long range, Investigation, Mapping and Prediction
CMA	Centrum voor Mariene Aardwetenschappen, Vrije Universiteit, Amsterdam
CNR	Consiglio Nazionale delle Richerche (Italia)
CNRS	Centre National de la Recherche Scientifique
CTD	Conductivity-Temperature-Depth
DCM	Deep Chlorophyll Maximum
DMS	Dimethylsulphide
DMSP	Dimethyl sulphoniopropionate
DNZ-RWS	Dienst Noordzee-Rijkswaterstaat Directorate North Sea, Ministry of Transport and Public Works
DOC	Dissolved Organic Carbon
DSDP/ODP	Deep Sea Drilling Project/Ocean Drilling Project
DUTCH-WARP	Deep and Upper Transport, Circulation and Hydrography, WOCE Atlantic Research Programme
EBM	Ester Based (drilling) Muds
EC	European Community
ECOPS	European Committee on Ocean and Polar Science
EGS	European Geophysical Society
EMBS	European Marine Biology Symposium
ENAM	European North Atlantic Margin
EPOS	European Polarstern Study
EROD	ethoxyresorufin-O-deethylase
ERSEM	European Regional Seas Ecosystem Model
ESF	European Science Foundation
FRIENDS	Food consumption/Faeces production, Respiration/Reproduction, Ingestion, Excretion/Egg production, Nutrition, Digestion/Development, Selectivity/Simulation studygroup
FYFY	Fysics-fytoplankton model
GC/HRMS	Gaschromatography/High Resolution Mass Spectrometry
GEOMAR	Forschungszentrum für Marine Geowissenschaften (Kiel)
GLOBEC	Global Ocean Ecosystem Dynamics
GOA	Geologie, Oceanografie, Aardwetenschappen Geosciences Foundation
IAPSO	International Association for the Physical Sciences of the Ocean
ICBP	International Council for Bird Preservation
ICES	International Council for the Exploration of the Sea
IfM	Institut für Meeresforschung, Hamburg, Germany
IFREMER	Institut Français de Recherche pour l'Exploration de la Mer
IGBP	International Geosphere Biosphere Program (under ICSU)
IMAU	Instituut voor Marien en Atmosferisch Onderzoek, Universiteit Utrecht Institute for Marine and Atmospheric Research
IMPACT II	The effects of different types of fisheries on the North Sea and Irish Sea ecosystem (EC-project proposal)
IMW-TNO	Instituut voor Milieuwetenschappen-TNO Institute for Environmental Sciences-TNO
INP	Integrated North Sea Programme
IOC	Intergovernmental Oceanographic Commission
IUCN	International Union for the Conservation of Nature
IWRB	International Wetland and Waterfowl Research Bureau
IWSG	International Wader Study Group
JGOFS	Joint Global Ocean Flux Study

KA	kiloyear
KNAW	Koninklijke Nederlandse Akademie van Wetenschappen Royal Netherlands Academy of Arts and Sciences
KNCV	Koninklijke Nederlandse Chemie Vereniging
KNGMG	Koninklijk Nederlands Geologisch-Mijnbouwkundig Genootschap
LGM	Laboratoire de Géochimie et Géomagnetisme, Université d'Aix-Marseille III, Marseille, France
LOICZ	Land Ocean Interaction in the Coastal Zone
LPP	Laboratorium voor Palaeobotanie en Palynologie, Universiteit Utrecht
LREE	Light Rare Earth Elements
LUW	Landbouw Universiteit Wageningen Agricultural University Wageningen
MA	million years
MAFF	Ministry of Agriculture, Fishery and Food (UK)
MAST	Marine Science and Technology programme
MATURE	Biogeochemistry of the maximum turbidity zone in estuaries
MERLIM	Marine Ecosystem Regulation: trace metal and carbon dioxide LIMitations (EU-MAST III)
MILZON	Inventariserend Macrobenthos Onderzoek in de Milieu Zonering op het Nederlands Continentaal Plat (Dir. Noordzee, RWS)
MIZ	Marginal Ice Zone
NAM	Nederlandse Aardolie Maatschappij Dutch Oil Company
NASS-4	North Atlantic Surface Seawater
NATO	North Atlantic Treaty Organization
NERC	Natural Environment Research Council (UK)
NIOO-CEMO	Nederlands Instituut voor Oecologisch Onderzoek-Centrum voor Estuariene en Mariene Oecologie Netherlands Institute of Ecology-Centre for Estuarine and Coastal Ecology
NIOO-CTE	NIOO-Centre Terrestrial Ecology
NIOP	Netherlands Indian Ocean Programme
NMI	Netherlands Measurements Institute
NMR	Nuclear Magnetic Resonance
NNI	Netherlands Normalisation Institute
NNM	Nationaal Natuurhistorisch Museum, Leiden
NOAA	National Oceanographic & Atmospheric Administration
NOP	Nationaal Onderzoeksprogramma voor luchtverontreiniging en klimaatverandering National Research Programme on Atmospheric Pollution and Climate Change
NOU	Nederlandse Ornithologische Unie Netherlands Ornithologists' Union
NOWESP	Northwest European Shelf Programme
NSF	National Science Foundation (USA)
NSO	Nederlands Stookolieslachtoffer-Onderzoek Dutch beached bird survey programme, working group of Dutch Seabird Group (NSO/NZG)
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek Netherlands Organization for Scientific Research
NZG	Nederlandse Zeevogelgroep Dutch Seabird Group
OBM	Oil Based (drilling) Muds
OCEAN	Ocean Colour European Archiving Network
OMEX	Ocean Margins Exchange
PAGES	Past Global Changes
PCB	Polychlorinated biphenyls
PEGASUS	PElagic Geographic Study of the Abundance of SUSpend matter
QUASIMEME	Quality Assurance of Information for Marine Environmental Monitoring in Europe
RCG	Rijks-commissie voor Geodesie State commission for Geodesy
RIKZ	Rijksinstituut voor Kust en Zee National Institute for Coastal and Marine Management
RIVM	Rijksinstituut voor Volksgezondheid en Milieuhygiëne National Institute of Public Health and Environmental Protection
RIVO-DLO	Rijks Instituut voor Visserij Onderzoek Netherlands Institute for Fisheries Research
RUG	Rijksuniversiteit Groningen University of Groningen
RUU	Rijksuniversiteit Utrecht University of Utrecht
RWS	Rijkswaterstaat Department of the Ministry of Transport and Public Works
SCOR	Scientific Committee on Oceanic Research
SEAS	Study of the European Arctic Shelf
SeaWIFS	Sea Viewing Wide-Field of view Sensor
SEM	Scanning Electron Microscope

SETAC	Society of Environmental Toxicology and Chemistry
SIMS	Stable Isotope Mass Spectrometry
SLW	Stichting Levenswetenschappen
SOVON	Stichting Ornithologisch Veldonderzoek Nederland
SOZ	Stichting Onderzoek der Zee Netherlands Marine Research Foundation
SPASIBA	Scientific Programme on Arctic and Siberian Aquatorium
SPMW	Subpolar Mode Water
SRON	Space Research Organization Netherlands
STED	Short-Term Dynamics in benthic microbial activities and nutrient fluxes related to sedimentation and current velocities in the Oystergrounds, North Sea
STEP	Science and Technology for Environmental Protection
TNO	Toegepast Onderzoek Nederland Applied Research Netherlands
TROL	Temperature Resistivity Oxygen Lander
TUD	Technical University Delft
UGGI	Union Geodesique et Geophysique Internationale International Union of Geodesy and Geophysics
ULB	Université Libre Bruxelles
VU	Vrije Universiteit Amsterdam Free University Amsterdam
VUB	Vrije Universiteit Brussel Free University Brussels
VvA	Verstoring van Aardsystemen (NWO)
WCRP	World Climate Research Programme
WOCE	World Ocean Circulation Experiment
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence